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GOVERNMENT SUPPORT FOR SYNTHETIC PIPELINE GAS UNCERTAIN AND NEE--ETC(U)
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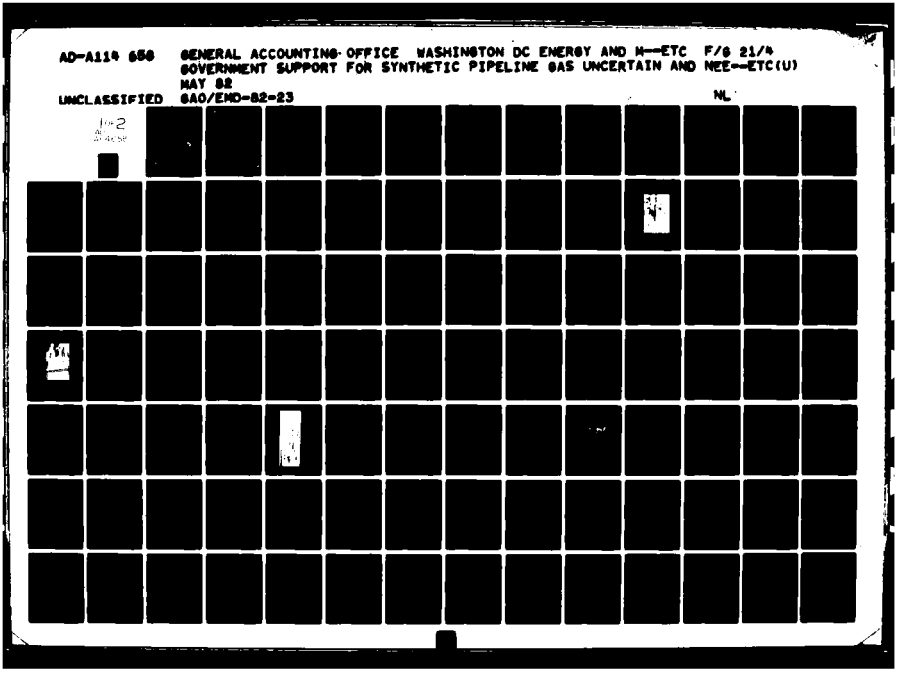

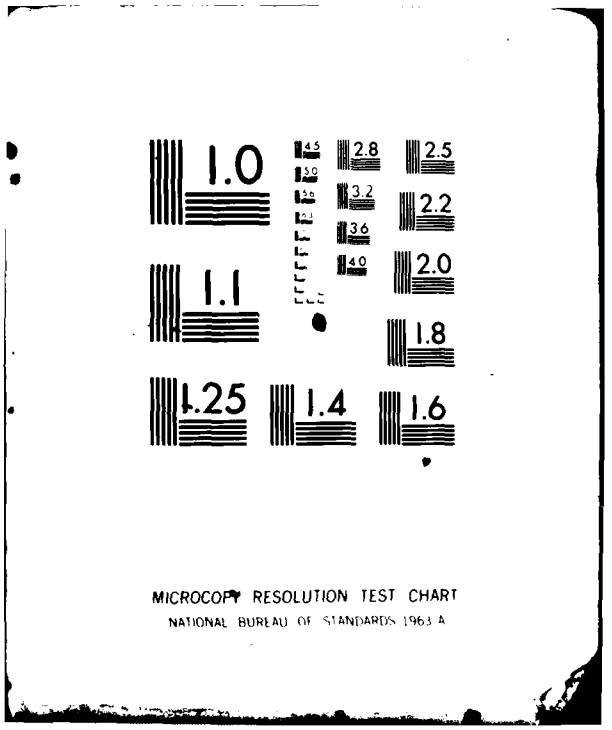
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BY THE U.S. GENERAL ACCOUNTING OFFICE

Report To The Secretary Of Energy

Government Support For Synthetic Pipeline Gas Uncertain And Needs Attention

GAO identifies DOE synthetic pipeline coal gas research and development which could be left to industry. Recent congresseional budget cuts and further DOE proposals, if enacted, will eliminate much of the R&D. Also, the Department's environmental research has been cut back beyond what industry will be required to perform, and leave a gap in needed efforts.

Because DOE's support for large scale demonstration projects has been eliminated, sponsors will likely have to look to the newly created Synthetic Fuels Corporation for Government financial assistance.

GAO identifies obstacles facing commercial projects and makes recommendations for focusing the Department's research and development, providing necessary environmental research and furthering consideration of coal gasification demonstrations.

GAO/EMD-82-23
MAY 14, 1982

UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

ENERGY AND MINERALS
DIVISION

E-206010

The Honorable James E. Edwards
The Secretary of Energy

Dear Mr. Secretary:

This report discusses Government and industry efforts to research, develop, demonstrate, and commercialize high-Btu coal gasification, and explores the problems and potential inherent in accelerating commercial-scale construction. It provides information on the opportunities for refocusing planning and support for coal gasification and describes matters the Synthetic Fuels Corporation should consider in developing its synthetic fuels program.

This report contains recommendations to you on pages 41 and 64. As you know, section 236 of the Legislative Reorganization Act of 1970 requires the head of a Federal agency to submit a written statement on actions taken on our recommendations to the Senate Committee on Governmental Affairs and the House Committee on Government Operations not later than 60 days after the date of the report and to the House and Senate Committees on Appropriations with the agency's first request for appropriations made more than 60 days after the date of the report.

We are sending copies of this report to the Director, Office of Management and Budget; the Chairman, Federal Energy Regulatory Commission; the Chairman, Synthetic Fuels Corporation; and interested congressional committees.

Sincerely yours,

for J. Dexter Peach
Director

U.S. GENERAL ACCOUNTING OFFICE
REPORT TO THE SECRETARY
OF ENERGY

GOVERNMENT SUPPORT FOR SYNTHETIC PIPELINE GAS UNCERTAIN AND NEEDS ATTENTION

D I G E S T

Converting coal into a substitute for natural gas is one approach that shows promise for supplementing gas supplies and reducing U.S. dependence on foreign energy sources. Because of technological progress and changing Government policies, this technology, called high-Btu coal gasification, has reached a crossroads. (See p. 9.)

Some private groups are seeking Government support for U.S. plants based on a "first-generation" process which has been used abroad for decades. Other groups have been considering a "second-generation" of advanced processes which have been proven in pilot plants and are now ready for commercial demonstration. Still others look to a third generation of even more advanced processes which are just beginning pilot plant testing. (See pp. 10 to 13.)

The Government has already spent millions of dollars and could spend much more assisting research, development, and commercialization of high-Btu gasification technology. GAO saw a need for an independent assessment of the results of this investment to help ensure that future funds would be spent wisely. The Department of Energy (DOE) provided most of the R&D support. Now, however, commercial-scale demonstrations including those for high-Btu gasification will have to look to the newly created Synthetic Fuels Corporation for government financial assistance. (See pp. 4 and 22.)

COMMERCIAL DEMONSTRATIONS WILL LIKELY DEPEND ON GOVERNMENT SUPPORT

While research and development for high-Btu coal gasification dates from World War II, no commercial size plants have been built, mainly because of economic and financing problems.

Commercial-scale demonstrations of the first and second-generation processes are now possible

and would help resolve economic uncertainties. In all likelihood these projects will continue to need Government support because of the huge capital investment and uncertain product costs. One first-generation plant is well on its way to beginning construction, with a price guarantee from Federal regulatory authorities and a conditional loan guarantee commitment from the Department of Energy. (See p. 45.)

With DOE providing no additional support for demonstration plants, the Synthetic Fuels Corporation is being looked to as the source of future Government funding for both commercial and near commercial processes. (See p. 22.)

Second generation could lend geographic balance

After a protracted, costly program, DOE has brought the second-generation of processes to the brink of commercial readiness, but the result has not been adequate to ensure commercial use. When Government support for the demonstration program ended in 1981, the second-generation processes had not fully attained their promise of improving on the costs of the first-generation. (See pp. 12, 28, and 42.)

However, because they can use additional types of coal, specifically those common in the Eastern United States, second-generation demonstrations could contribute diversity of resources as well as geographical balance to the Corporation's program and avoid an overcommitment to western plants. (See pp. 50 to 52.)

GAO believes DOE could assist the Corporation by assessing the importance of the second-generation and other coal gasification processes to the Nation's potential for using coal. As part of this evaluation, DOE needs to consider other coal gasification and indirect liquefaction options. GAO believes the Corporation needs this assessment within the near future, or 90 days, while it still has the time and money to consider support for projects using eastern coal. (See pp. 58, 63, and 64.)

Cost and Need Dictate A Cautious Approach

While Government-supported commercial demonstrations are now possible and would permit a better assessment of the potential for an industry to develop new gas supplies, the high capital costs, the higher costs of synthetic gas, and the uncertain need for high-Btu gas in the near term will warn against a sweeping commitment to coal gasification. (See pp. 17-. 22.)

NEED TO BETTER FOCUS RESEARCH AND DEVELOPMENT

The administration has adopted a policy of funding only long-term, high-risk, but high-payoff research; however, DOE has not defined these terms nor established adequate overall criteria for funding research and development. (See pp. 24 and 25.)

DOE believes that the funding of second generation demonstrations projects is the responsibility of industry and has dropped continued support. Until recently, DOE continued to support other activities that GAO believes could also be left to industry. For example, DOE supported one third-generation process where the industrial sponsor was willing to support its process on a stretched out timetable. As GAO was processing this report, the Congress eliminated support for this project. Also, consistent with GAO views, DOE has taken action to further cut research and development which could be left to industry. (See pp. 22, 30, and 31.)

On the other hand, DOE is moving away from environmental research which had been recognized as the responsibility of Government. Some of this research was eliminated when DOE dropped support for the second-generation demonstration projects. Similar research which is beyond what industry will be required to perform will still be needed on first of a kind commercial plants. (See pp. 33 to 36.)

To ensure research and development is appropriately focused, DOE needs to define an overall funding criteria and establish guidelines and benefits for Government support of particular technologies like high-Btu coal gas.

RECOMMENDATIONS

GAO recommends that the Secretary of Energy

--establish a plan to guide future support of high-Btu coal gasification energy research and development. The plan should be based on clear policy objectives and defined criteria which will set the general limits of Government support in the context of overall energy research and development. Also, the plan should recognize research that is more appropriately funded by industry, and include essential environmental research that is beyond the responsibility of industry. (See p. 41.)

--evaluate the importance of the high-Btu second-generation process as a method of using eastern coal, and the prospects for accelerating the processes as commercial scale modules. As part of this evaluation DOE also needs to consider other coal gasification and indirect liquefaction options. (See p. 64.)

--report, within 90 days of the date of this report, to the Synthetic Fuels Corporation's Board of Directors on the potential role of second-generation processes in the synthetic fuel program, the availability of information needed for commercialization, product costs and markets, and technical and environmental risks. (See p. 64.)

AGENCY COMMENTS

GAO provided draft copies of this report to DOE, the Synthetic Fuels Corporation, OMB, and the Federal Energy Regulatory Commission for their comments. Except for OMB, the agencies responded in time for GAO to consider their comments in this report.

The Synthetic Fuels Corporation said the report provides a useful perspective to many issues but felt GAO's emphasis on high-Btu gas unnecessarily narrowed the focus of the report. GAO disagrees with this comment since the report makes reference to other coal gasification and related indirect liquefaction technologies and recommends that DOE considers them in evaluating the importance of high-Btu coal gasification.

DOE did not agree with the report in general, but did agree with GAO's recommendations that energy research and development be funded according to national priorities. DOE stated that a critique of large-scale practical demonstration projects in terms of the characteristics of routine small-scale research and development is inappropriate and misleading. While GAO recognizes that there are basic differences expected from large and small scale research projects, GAO believes that the report recognizes these differences. GAO believes that both large and small research and development projects need to be fully justified on a basis consistent with the overall Government policy objectives, defined research and development criteria and specific technology strategics.

The Federal Energy Regulatory Commission said that it had reviewed the report and had no comments to provide.

GAO carefully considered the comments, and where appropriate, made changes. The agencies' views and GAO's evaluation begin on page 65.

Contents

ABBREVIATIONS

Btu	British thermal unit
DOE	Department of Energy
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
FERC	Federal Energy Regulatory Commission
GAO	General Accounting Office
GRI	Gas Research Institute
ICGG	Illinois Coal Gasification Group
OMB	Office of Management and Budget
RCRA	Resource Conservation and Recovery Act
R&D	Research and development
RD&D	Research, development, and demonstration
Sasol	South African Coal, Oil, and Gas Corporation Limited
SFC	Synthetic Fuels Corporation
TSCA	Toxic Substances Control Act

GLOSSARY

Bituminous coal	An intermediate-rank coal with low to high percentage of carbon, intermediate to high heat content, a high percentage of matter that is easily vaporized, a low percentage of moisture, and a tendency to cake when gasified.
British thermal unit (Btu)	The amount of energy necessary to raise the temperature of one pound of water by one degree Fahrenheit.
Caking (coal)	The tendency of some coals to melt and stick together when gasified or burned, ultimately forming or hardening into a mass or clinker.
Combined cycle	Combination of a steam turbine and a gas turbine in an electrical generation unit.
Demonstration plant	A facility scaled up from the pilot plant to minimize the uncertainties of scaling up to a commercial plant and validate productivity, economics, and environmental performance. It may use commercial-scale equipment and be designed as a modular unit of a commercial-size plant. In this way it can be expanded to a full-size commercial plant at the same site if the demonstration is successful.
Direct liquefaction	Process used to convert coal to liquid fuels by using process-derived solvents. (see app. I.)
Gasification of coal	Commonly refers to the conversion of coal to a gaseous form by any of a variety of chemical processes.
Gasifier	A vessel in which gasification occurs.
High-Btu gas	An equivalent of natural gas, predominately methane; energy content is usually 950 to 1,000 Btu per cubic foot.
Indirect liquefaction	Process used to convert coal to liquid fuels using gasification as a first step. (See app. I.)

Lignite	The lowest ranked coal with low heat content and carbon and high percentages of matter that vaporizes easily and moisture; an early stage in the formation of coal.
Low-Btu gas	Gas obtained by partial combustion of coal with air; energy content is usually 100 to 200 Btu per cubic foot.
Medium-Btu gas	Gas obtained by partial combustion of coal with steam and oxygen; energy content is usually 200 to 600 Btu per cubic foot.
Methanation	A process by which the heating value of gases containing hydrogen and carbon monoxide may be increased. It entails a catalytic reaction to form methane and, with the proper synthesis gas composition, can produce a gas having a heating value approaching that of natural gas (1,000 Btu per cubic foot).
Methane	A colorless, odorless, flammable, gaseous hydrocarbon that is a product of the decomposition of organic matter in marshes or mines or the distillation of coal.
Pilot plant	A generic term which may be broadly defined as a process research facility, scaled up from the process development unit and used to test and refine the process and prove technical feasibility. The pilot plant uses commercial-type (not commercial-size) components and is fully integrated for sustained operation. Pilot plants may require continual modification during testing but are generally dismantled or abandoned once tests are completed. DOE has defined a coal conversion pilot plant as a facility capable of processing more than 25 tons of coal per day.
Process development unit	A process research facility of intermediate size between bench scale and pilot plant. Defined by DOE as being able to process less than 25 tons of coal per day, this type

	of facility may or may not fully integrate all components of the process.
Reserves (coal)	The portion of coal resources in the ground that can be economically extracted at current prices (costs) using current technology.
Resources (coal)	Coal deposits in the ground as of a stated date, without regard to the technical or economic feasibility of extraction.
Slag (slagging)	Slag is molten ash and slagging refers to the operation of a gasification unit such that the ash melting temperature is exceeded, causing the ash to be discharged as a viscous melt or an agglomeration of tacky particles rather than a free-flowing powder.
Subbituminous coal	A low-rank coal with low fixed carbon and high percentages of volatile matter and moisture. Found primarily in the Western States, it has a low caking tendency.
Synthesis gas (syngas)	A generic term for mixtures of hydrogen and carbon monoxide with minor diluents (nitrogen and carbon dioxide) which are to be used as feedstock for subsequent processing steps.
Tailgate (price or cost)	The point on a pipeline where the finished high-Btu gas is delivered from the plant proper; hence, the price or cost of the gas at that point.
Wellhead (price)	Price of natural gas when it passes from the producer to the pipeline transmission company.

CHAPTER 1

INTRODUCTION

Abundant U.S. reserves of coal are an important resource in the Nation's drive to free itself from dependence on foreign suppliers of energy. Converting this coal into a substitute for natural gas is one idea that shows promise for supplementing gas supplies and displacing imported oil. Several Government agencies, industry groups, and private companies have become involved in efforts to exploit this technology, known as high-Btu coal gasification.

THE AMERICAN ENERGY QUANDARY

The United States is in the early stages of a drive to reduce its dependence on oil as its principal source of energy. Because oil reserves are inadequate to meet its fuel needs, the Nation has had to rely on imported oil. In 1979 the United States imported about half its oil supply, which provided about half its energy use. This reliance has grave consequences for U.S. economic and military security. Moreover, even the comparatively large foreign resources of oil will eventually be exhausted, so alternative supplies of energy must be found.

Economically, the rising price of imported oil has hurt the United States at home and abroad. Because oil is an essential fuel for transportation, higher oil prices have had an inflationary affect on virtually all types of goods and services.

The largest reserves of oil are concentrated in the politically unstable Middle East. Militarily, oil products are essential for delivering soldiers, supplies, and firepower. Dependence on these reserves by the United States and other nations is a constant threat to world peace. If these reserves should fall into hostile hands, the United States would be at a gross disadvantage.

During 1973-74, some Middle East countries brought these points home by refusing to sell their oil to the United States. They followed this embargo with large price increases. Moreover, U.S. natural gas reserves had begun dwindling, and it seemed the Nation might soon be importing more natural gas, as well as oil.

These trends led the Government to an intense planning effort to find a solution to dependence on imported energy. Conservation and fuel efficiency, pricing and production policies, increased exploration, development of unconventional sources and new technologies, Government assistance and deregulation are possible solutions. Each of the solutions has a role to play; however, each has uncertain consequences, so the quandary remains. What actions are needed, what are their costs, and how much would they help? While these questions await answers, the Nation remains unprepared for supply disruptions.

Out of the bewildering array of factors and alternatives, though, a few truths emerged:

1. The United States will depend for some time on fossil fuels. 1/

2. Reserves of oil and natural gas are being depleted.

3. The Nation's most abundant fossil resource, coal, is playing a minor role in energy production.

SYNTHETIC FUELS: A TRANSITIONAL SOLUTION

Ultimately, the Nation will have to find a renewable or inexhaustible source of energy, such as solar power. The technology to exploit such sources efficiently, however, is still far off. In the transition, a major secure source of energy for the United States can be synthetic fuels.

"Synthetic fuels" are substitutes for petroleum and natural gas derived from other natural resources such as coal, shale, and tar sands (porous rock or sediment deposits containing bitumen, a petroleum constituent). Coal and oil-bearing shale are the largest potential sources, comprising over three-fourths of estimated U.S. fossil energy resources, which include conventionally and unconventionally produced oil and gas. At current rates of consumption, coal and oil shale reserves could supply total U.S. energy needs for more than 150 years. While oil shale evidently has a role to play in an eventual synthetic fuel industry, coal is much more abundant and widespread. Recoverable reserves of U.S. coal contain enough energy to replace imported oil at current rates of consumption for nearly 4 centuries, assuming the coal could be extracted cleanly and economically. Various methods are available to exploit this coal.

COAL CONVERSION

The most obvious way to use coal is to burn it. Most coal is used in this manner in electric power plants and heavy industry. However, uncontrolled burning results in air pollution, particularly if the coal contains large concentrations of sulfur, like much U.S. coal. Eliminating the pollution is very costly and more practical at large scale. Therefore, methods of converting coal to substitutes for cleaner burning fuels, such as oil and natural

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1/Fossil fuels include coal, oil, natural gas, tar sands, and oil-bearing shale. They were formed over millions of years by geological pressure on dead organic matter. Because of the long time required for their formation, they must be considered a finite resource.

gas, have become a hope for an environmentally and ecomonically acceptable way of using coal and arriving at an acceptable alternative to imported energy.

As implied, there are two broad types of coal conversion: to liquid products similar to petroleum derivatives, or "liquefaction," and to gaseous products similar to natural gas, or "gasification." These technologies are closely related. Some processes are designed to produce both liquid and gaseous fuels; some to produce principally one or the other.

Coal can be gasified in plants designed for the surface or underground where it is found. Underground gasification reduces mining and the environmental and health hazards associated with coal. However, according to DOE officials, underground gasification is not likely to be developed in the near future because of the state-of-the-art of the technology.

Gaseous products are classified according to their energy content. This content is measured in British thermal units (Btu's), a convenient standard that can be used to measure energy from any resource. 1/ Thus coal gas can be low-Btu, medium-Btu, or high-Btu, depending on the conversion methods used. (See app. I.)

Our review focused on high-Btu coal gasification. High-Btu gas, at about 1,000 Btu per cubic foot, is equivalent to natural gas and can be substituted for it in an extensive nationwide pipeline system. Natural gas supplies more than half the country's residential and commercial establishments and nearly 40 percent of the energy consumed in industry and agriculture. Thus synthetic high-Btu gas has the potential for immediate use in almost every energy sector except transportation.

Virtually all high-Btu gasification processes entail similar steps. Coal is crushed and fed into a "gasifier," where it is heated in the presence of steam and oxygen. The resultant gas is then cleaned to remove impurities--notably sulfur, the chief source of pollution from coal burning. This sulfur, which has industrial uses, can then be sold as a byproduct, instead of fouling the atmosphere.

AGENCIES INVOLVED WITH HIGH-BTU COAL GASIFICATION

Several governmental and quasi-governmental agencies play a part in the coal gasification picture. Thus far, the thrust of

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1/A British thermal unit represents the energy required to raise the temperature of a pound of water by 1 degree Fahrenheit. The United States consumed 78 quadrillion Btu's, or 78 "quads," of energy in 1978. (A quadrillion is a million billion.)

their efforts has been to promote research and development (R&D) leading to commercial use of this technology. However, some of them have regulatory responsibilities and will become more involved once coal gas plants begin operation.

Department of Energy and predecessors

The Federal agency most involved with coal gasification has been the Department of Energy (DOE). DOE is a relatively new Department, formed in 1977 to provide the framework for a comprehensive and balanced national energy plan by coordinating and administering Federal energy functions. Among other things, DOE is responsible for the research, development, and demonstration (RD&D) of energy technology.

Federal involvement in RD&D for coal gasification, however, predates DOE's formation by a long stretch. It began at the end of World War II, with the Office of Synthetic Liquid Fuels in the Department of the Interior. The sponsor of the legislation that created this Office to demonstrate synthetic fuel technology stated:

> "* * * Without such a program we shall become an importer of petroleum and thus dependent on other lands and other peoples for the fuel supply we must have to maintain the commercial and industrial leadership that America now enjoys. * * *"

In the 1960s, responsibility for coal gas passed to Interior's Office of Coal Research, whose mission was to find a clean, economical use for coal. It was established because of concern that the large domestic reserves of coal were playing a disproportionately small role in U.S. energy use.

The Energy Research and Development Administration (ERDA), established in 1975, absorbed coal research responsibilities. The Middle East oil embargo of 1973-74 showed that the United States needed to consolidate and better coordinate Federal R&D for all types of energy technology. Finally, the creation of the Department of Energy further consolidated the major Federal agency energy functions, including RD&D, regulation, conservation, power marketing, data collection, and even military applications and safeguards.

Three offices in DOE have or had responsibilities related to coal gasification. The Assistant Secretary for Fossil Energy is responsible for RD&D programs involving fossil fuels. DOE's budget provided around $50 million for high-Btu gasification RD&D in fiscal year 1981. The Assistant Secretary for Resource Applications managed programs to demonstrate and encourage the commercial use of developed energy supply technologies. This office made commitments for $63 million in assistance to high-Btu projects in 1980, but was recently abolished. The Assistant Secretary for Environment ensured that DOE's programs were consistent with

environmental and safety laws, regulations, and policies. This position was recently retitled and environmental and health research was shifted to the Office of Energy Research.

The Synthetic Fuels Corporation (SFC) has been created as a Government "banker" for a synthetic fuels program. The importance of the program is found in the Energy Security Act of 1980 (Public Law 96-294, June 30). Its purposes are " * * * to improve the Nation's balance of payments, reduce the threat of economic disruption from oil supply interruptions, and increase the Nation's security by reducing its dependence upon imported oil." The Corporation is the catalyst.

The Energy Security Act set a national goal of producing 500,000 barrels of oil per day in synthetic fuels by 1987 and four times as much by 1992. The corporation will have about $18 billion through 1984 to provide various types of financial incentives to private sector sponsors of commercial synthetic fuel projects from domestic resources such as coal and oil shale. In 1984 the corporation will submit a comprehensive strategy for further synthetic fuel development to the Congress. The strategy will be based on the economic, technical, and environmental experience of projects funded by the corporation. The Congress could allocate up to an additional $68 billion through 1992 to implement the strategy. Other aspects of the SFC and how they impact on high Btu coal gasification are discussed in chapter 4.

Regulatory agencies

Because high-Btu coal gasification has not been established commercially, little regulation, as such, has yet occurred. However, two Federal regulatory agencies have played and will play an important role in its development.

The Environmental Protection Agency (EPA) is charged with protecting and enhancing the Nation's environment. It controls air and water pollution, solid waste disposal, and the handling of toxic substances. A new production facility, such as a coal gas plant, must not violate any of the numerous laws that EPA enforces.

DOE has identified 21 Federal laws, protecting everything from clean air to bald eagles, that will affect the siting, construction, and operation of synthetic fuel plants. Two of the most significant are the Resource Conservation and Recovery Act (RCRA), which governs the disposal of mining and plant wastes, and the Toxic Substances Control Act (TSCA), which governs the handling of plant products and byproducts.

Besides EPA, numerous State and local authorities will have to approve the construction of high-Btu gas plants. In some cases their standards may be more difficult to meet than EPA's.

An atmosphere of uncertainty surrounds environmental regulation of gasification. While, high-Btu plants have been judged to be environmentally acceptable, much more needs to be known about their environmental and health effects. Second, EPA has many decisions to make about how important laws such as RCRA and TSCA will be implemented. Regulation is expected to add substantially, but somewhat unpredictably, to the cost of coal gas.

Another type of regulation is represented by the Federal Energy Regulatory Commission (FERC), an independent agency within the Department of Energy. When FERC was created along with DOE in 1977, it inherited the responsibilities of the Federal Power Commission. It exercises broad regulatory authority over natural gas and electric energy production and marketing.

FERC's role in coal gasification stems from its authority to regulate natural gas. It sets prices for the sale of gas and controls gas transportation, including the pipeline system. In its price-setting, or ratemaking function, it represents the interests of gas customers, sometimes called ratepayers, who depend on particular gas suppliers for their fuel needs. As part of assuring gas suppliers a fair price for their product, FERC allows them to pass on to the ratepayers the cost of research and development, provided it is in the ratepayers' interest.

Industry research groups

The Gas Research Institute (GRI), an independent, nonprofit scientific organization, does a large part of this R&D. The institute, established in 1976, plans and manages a coordinated R&D program, including coal gasification, for the benefit of the gas consumer. It absorbed R&D responsibilities of the American Gas Association, which continues as an industry advocate.

The institute is funded by gas pipeline and distribution companies, but its budget is subject to FERC review. Annually, it submits a 5-year plan for R&D and FERC approves the budget for the first year. The institute spends about half its funds on projects to increase the supply of gas and about a third on conservation research. It does not carry out research itself, but contracts with laboratories, universities, etc. It often funds projects jointly with DOE and other institutions.

Other private groups also carry out gas R&D, including coal gasification. Gas companies fund projects independently--some from gas sales with FERC approval, others with company capital. Other companies not under FERC jurisdiction (oil companies, for example) are likewise in this field.

OBJECTIVES, SCOPE, AND METHODOLOGY

During 1980 it was clear that the Government would be faced with decisions to spend hundreds of millions, if not billions, of

dollars in assisting high-Btu coal gasification. DOE was reviewing proposals to demonstrate advanced gasification technology as part of its RD&D program.

At the same time, the Congress had mandated a commercial incentive program to promote the production of synfuels from domestic resources. In keeping with our efforts to provide the Congress with independent information on major Government decisions, we undertook a review of high-Btu coal gasification, as a synthetic fuel technology with immediate commercial potential. Although the authorizing legislation had passed after lengthy debate and still had some opponents, we assumed that the Congress had made its decision and the commercialization program would go forward.

Our objective was to examine the role of high-Btu gasification in both the RD&D and commercialization programs and explore the problems and potential inherent in accelerating its commercial deployment. More specifically, we were interested in whether the Government's R&D program was consistent with current Government policies, how the Government might allocate its limited funds to get the most benefit, and how the involved agencies might coordinate their efforts to accelerate deployment. Meeting these objectives entailed some comparisons between high-Btu coal gasification processes and other synthetic fuel technologies; however, we did not assess the merits of the processes or technologies in depth.

We interviewed officials at DOE, EPA, FERC, the Office of Management and Budget (OMB), the Synthetic Fuels Corporation, and the Army Corps of Engineers (which has contract management responsibilities for the demonstration projects) and reviewed documents they provided, as well as other published information. At DOE and SFC we interviewed officials responsible for implementing policies and planning the programs, as well as those directly involved in evaluating and managing the funding for projects. To understand the objectives and views of industry, we contacted the American Gas Association, the Gas Research Institute, and the National Coal Association.

Based upon discussions with such officials, we selected the three demonstration plant proposals and the three commercial plant proposals that seemed to be the frontrunners in the competition for Federal funds. All six projects had received some DOE funding. The three demonstration projects (Slagging Lurgi process advanced by Conoco), the Illinois Coal Gasification Group (Cogas process), and the Institute of Gas Technology (Hygas process) were to be developed under DOE's Research, Development, and Demonstration Program; 1/ however, this route was closed by the new

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1/See appendix II.

administration's change in policies. The three commercial projects--Great Plains, Wycoal gas, and Tri-State (all variations of the Lurgi process)--were to be developed under DOE or SFC's program with FERC tariffs. Final, but seemingly unique, DOE commitments are expected for the Great Plains project in early 1982. Wycoal gas in September 1981 decided it would slow its project activities because of lack of encouragement from either DOE or SFC. Tri-State is looking to the SFC for assistance.

We interviewed the major project sponsor, State officials for the proposed locations, and the developers of the processes to be used, and reviewed documents they provided. Our review was directed to understanding the history and status of the projects and the technical, economic, financing, environmental, and other regulatory problems which slowed their development. The results of our interviews and our review of records were combined in a summary of the project's status as of May 1981. Updates of major changes through September 1981 are included in appendix II.

The facts and opinions we collected and analyzed led to our assessment of the technology's obstacles and potential. We did not attempt the task of verifying the large amounts of data collected. Rather we compared information received from diverse sources to obtain a balanced picture as of mid-1981. Changes continued or were contemplated as we completed our review. We took into account those changes which we judged to have a major impact on our report. For example, we reviewed the budget changes made by the Reagan administration to the 1981 and 1982 programs. We reviewed related congressional actions through November 1981 as part or our evaluation of agency comments. Finally, we avoided any speculations of the possible impacts of certain legislative measures which are receiving congressional and administration attention such as early deregulation of the gas industry, the complete dismantling of DOE, or repeal of the Power Plant and Industrial Fuel Use Act.

Our review was done consistent with the "Standards for Audit of Governmental Organizations, Programs, Activities, and Functions."

CHAPTER 2

HIGH-BTU COAL GASIFICATION AT A CROSSROADS

Since World War II, industry and Government have been researching and developing coal gasification. This work has concentrated on step-by-step development of advanced, or second-generation, processes, because existing, or first-generation, processes were considered technically limited and uneconomical. By the mid-1970s, second-generation research had advanced to the point that large demonstration plants became the next planned step. Meanwhile, realization of the Nation's need for a reliable natural gas supply brought renewed industry interest in first-generation technology. In 1975 a major gas supplier sought Federal help in financing a commercial synthetic fuel plant--the Great Plains coal gasification project. Then, during 1978-80 the Carter Administration urged and the Congress mandated the development of a commercial synthetic fuel industry and set up mechanisms, including the Synthetic Fuels Corporation, to speed its development with Federal funds. Coupled with the plans for demonstration plants, this development meant the Government would probably soon be spending much more on coal gasification than it had in the past.

Recently, however, new found sources of natural gas have diminished the urgency of finding a synthetic substitute. Because high-Btu coal gas will be more costly than currently available gas and oil alternatives, a full-blown industry is unlikely in the near future.

Moreover, 1981 ushered in a new administration and presaged another change in direction for Federal involvement in energy development. Operating in an atmosphere of frugality and under the principle of leaving near-commercial and commercial technology development to industry, the Reagan administration called for cutbacks in large-scale demonstrations and abolished the arm of the Department of Energy that managed commercialization efforts. Further, while the President envisions SFC as playing a major role, it is not yet operational. The eventual impact of the new administration's policies on high-Btu coal gasification will remain unclear for some time.

As the impetus for large Government spending on coal gasification runs into ample supplies of gas and the new emphasis on Government thrift, several important issues need to be resolved.

--Is continued Government support needed for technical and environmental research, development, and demonstration?

--Can the demonstration projects survive under the Synthetic Fuels Corporation financing criteria?

--Should the Government assist the construction of commercial plants and at what level?

--How can projects be chosen to give the greatest benefit for the least expense?

COAL GASIFICATION TECHNOLOGY ON LONG PATH OF DEVELOPMENT

Coal gasification processes have been under development for decades. Before cheap, convenient natural gas became available, coal gas was a widely used fuel. Since then, private and federally assisted R&D in the United States have focused on improving gasification technology for the day when it would become economically viable.

Closing the generation gap

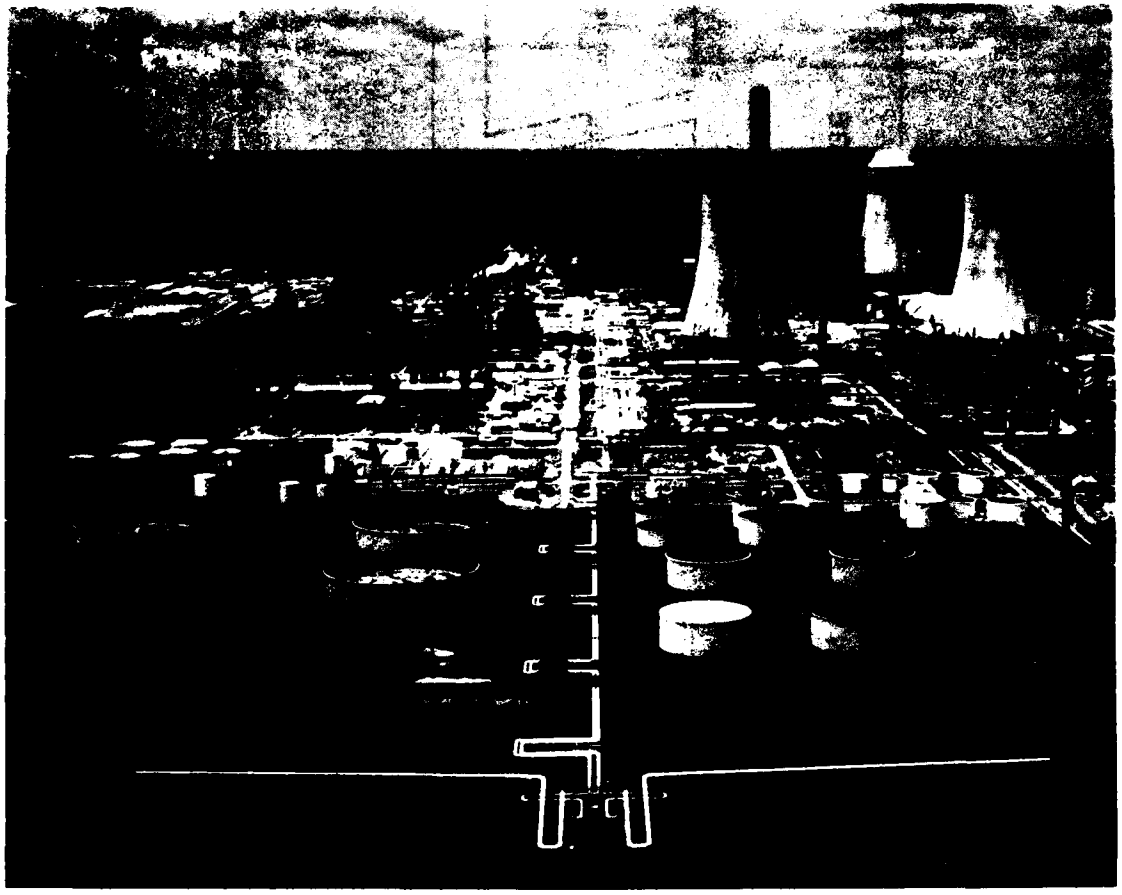
Commercial use of coal gasification dates from the 19th century. By the mid-1920s an estimated 11,000 coal gas plants supplied lighting, cooking, and industrial fuel to the United States. After World War II, cheaper natural gas, oil, and electricity took over these markets domestically.

Abroad, however, in countries where oil and natural gas are less plentiful, coal gas production continued and governments supported advances in the state of the art. Their efforts led to mature gasification processes like the German Lurgi process, first used in 1936 and later employed in the Sasol plants in South Africa. These plants produce medium-Btu gas as a step towards liquid fuels; however, this gas can also be upgraded to high Btu by existing technology. The gasification processes now in commercial use overseas are known in the United States as the "first generation" of processes.

While developers abroad refined the first generation, U.S. researchers concentrated on a second generation. The second generation promised 15 percent more efficiency than existing technology, thus it might prove more competitive as a source of fuel. Moreover, it offered reduced pollution. Finally, first-generation processes worked best on certain types of coal, common only in the Western States. The East, however, offered equally large reserves of coal, much larger supplies of water (important in coal gasification), larger gas markets, and more skilled labor and manufacturing resources. Thus, developing processes that would effectively use eastern coal, as well as increase efficiency and reduce pollution, became important.

Federal assistance and independent efforts

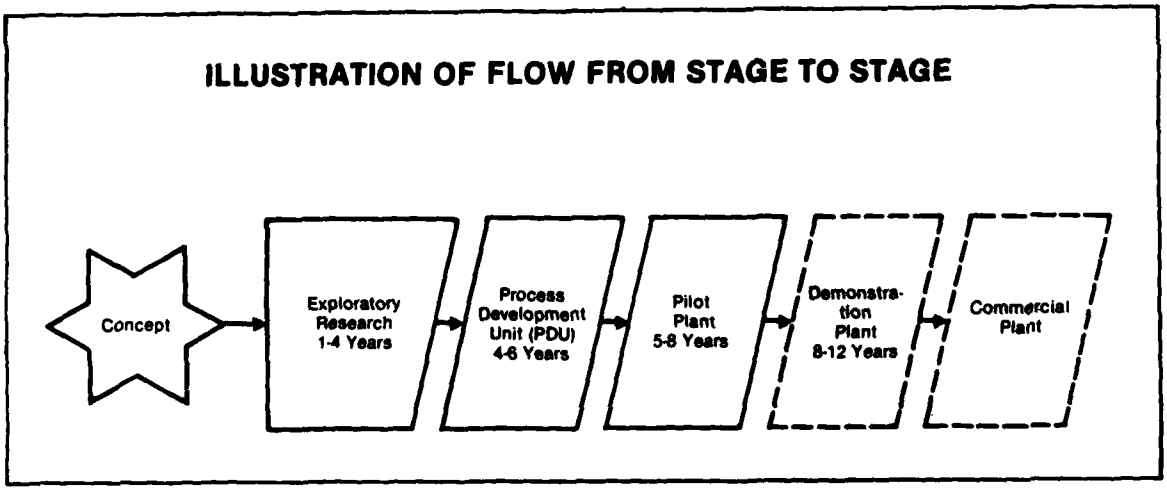
The Federal Government helped fund much of this work, though some proceeded independently. The Government's support evolved gradually from long-range research towards demonstration of



AERIAL VIEW OF SASOL 2 PLANT NOVEMBER 1979
(COURTESY OF TEXAS EASTERN SYNFUELS, INC.)

commercial technology. The evolution followed the normal course of step-by-step development of a new technology, but also responded to changing objectives. The level of funds committed meanwhile accelerated.

DOE and its predecessors advanced the second generation toward commercialization with a series of small steps to minimize the funds risked, as shown below. (Definitions of the three intermediate stages can be found in the glossary.)



After each step, the Government and the developer must decide (1) whether to abandon or shelve the process or proceed to the next step and (2) how much continued Government involvement is appropriate. These decisions generally result in narrowing down the processes advanced.

Each generation of high-Btu coal gas technology is at such a decision point. The first generation is ready for the last step, a commercial plant, while second-generation processes have completed pilot testing and were vying for demonstration plant support during 1976-81. Yet a third generation has completed testing at the process development unit and is ready for pilot testing.

Government support has been channeled through a number of programs that responded to different objectives. In the 1960s with coal use declining, the Office of Coal Research focused on long-range, small-scale research to find a clean, economical use for coal. In 1971, it joined with the American Gas Association in a much larger program to develop several second-generation processes to meet apparently failing natural gas supplies; this effort became known as the joint program. The Energy Research and Development Administration took over the Government's share of this program in 1975, while starting a separate program for a near-term demonstration of still other second-generation processes. These programs continued under DOE, which focused on coal gas as a means of displacing imported oil.

Throughout, the Government pursued a philosophy of supporting several processes in order to reduce the time required to have at least one viable alternative to the first-generation gasification processes available when needed. Meanwhile, the commitment of funds to high-Btu gasification mounted, though the total amount is hard to ascertain. The joint program, supported two-thirds by Government funds and one-third by ratepayer contributions (through the American Gas Association and later the Gas Research Institute), spent $293 million during 1971-80. Both the Government and the institute pursued independent efforts outside the joint program; for example, the Government funded a demonstration program supporting other processes and the institute funded generic research with benefits to more than one process. These efforts cost more than the joint program did during 1977-80. Further, individual gas companies passed on $5.1 million of gasification research to their customers during 1976-78. Other funds have come from unregulated oil companies and from gas companies' profits when they could not obtain approval for ratepayer relief.

RECENT DRIVE FOR COMMERCIAL DEPLOYMENT

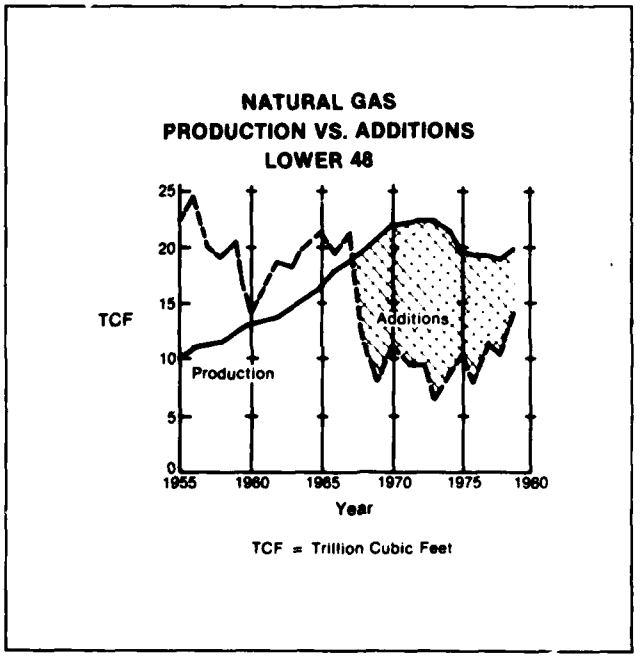
As research and development for the second generation progressed, growing realization of the need for an alternative to conventional fuels sparked new interest in first-generation technology. Oil prices were rising with no end in sight while natural gas supplies were failing, making coal gas more attractive. The most striking evidence of this trend was the emergence of the Great Plains gasification project about 1975. Then, in 1978-80 the President and the Congress joined efforts in a bold new step, mandating Federal support for a synthetic fuel industry.

Gas shortages predicted

The extent of U.S. natural gas resources has never been easy to measure. Although estimates vary widely, everyone agrees that conventional natural gas will eventually run out. In the late 1960s, projected shortages in supply heightened this concern.

The most certain measure of gas supplies is proven reserves--resources that are economically recoverable using existing technology and whose location, quality, and quantity are known. In the future, the extent of proven reserves will depend on new discoveries of gas, the price at which gas will be sold, and new recovery technology--all of which are unpredictable.

Since 1970 proven U.S. natural gas reserves have been declining; that is, new gas available has not kept up with production. The crosshatched area in the following chart indicates where yearly production exceeded yearly additions to reserves. Quite obviously, the gas supply will eventually be exhausted if this trend continues.



SOURCE: A 1980 Report of the American Gas Association's Gas Supply Committee.

Concern reached a climax in the severe winter of 1976-77, when shortages of natural gas caused factory closings that idled over 1 million workers in certain areas of the country. Other areas, however, seemed to have adequate supplies. This crisis had two results. First, industrial gas customers began switching to other fuel sources, such as oil and imported natural gas. Second, the Congress passed legislation in 1978 that included

-- the Power Plant and Industrial Fuel Use Act restricting the use of oil, and natural gas, thereby encouraging the use of coal, and

-- the Natural Gas Policy Act, permitting more even allocation of gas supplies and providing for gradually removing controls on the wellhead price of gas (the price pipelines pay producers) to stimulate production.

Gas production began to increase in 1979, which, combined with fuel switching and conservation, has led to a surplus in the past few years. This surplus, called the "gas bubble," is considered temporary, however.

In June 1981, GAO offered its views on future natural gas supplies before the Subcommittee on Fossil and Synthetic Fuels, House Committee on Energy and Commerce. Through the remainder of the century, the gap between domestic natural gas production and consumption is expected to grow, there will be a shift away from dependence on conventional supplies to a variety of other sources, and a continued dependence on gas imports. Although it is too early to tell what impact research and development will have, if domestic supplies increase, gas imports could be reduced or OPEC oil could be displaced.

Industry interest strong but insufficient to build plants

The threatened shortage of natural gas and the trend towards switching were understandably worrisome to gas companies, who depend on a steady supply and demand for their survival. In the early 1970s, when reserves began to shrink, several of these companies began to consider coal gasification as an alternative source. By 1973, 10 natural gas pipeline companies had announced plans to construct high-Btu gas plants. In 1975 various sources projected 3 to 7 commercial gas plants by 1980 and 15 to 63 by 1990. More than 100 sites have been identified where adequate coal, water, and environmental flexibility are sufficient for high-Btu gasification plants.

Of the commercial proposals we reviewed, Great Plains and WyCoalGas responded to the early concern about supply. Although Tri-State was not among the early projects, at that time its primary sponsor was managing another proposed commercial high-Btu coal gasification plant, Wesco in New Mexico.

Despite the intense interest, no plants were actually built. Some plans never advanced beyond feasibility studies. More serious projects such as Wesco ran into difficulties like securing a site or satisfying environmental regulations. Companies seeking to build plants also needed regulatory approval to market the gas before starting construction. The biggest stumbling block,

however, was uncertainty that the plant would produce gas economically, which made financing arrangements all but impossible. To overcome the financing obstacle, companies looked to the Federal Government for support in the form of loan guarantees. Though bills to provide this kind of support were introduced in the Congress, it was not immediately forthcoming. As time passed, companies abandoned their plans or shelved them, until by 1978 only one group of sponsors was actively trying to advance their project, Great Plains.

Legislation sparked renewed interest

Finally, congressional support began to gather momentum. During 1978-80 at the urging of President Carter, the Congress passed a series of laws establishing synthetic fuel production goals, a new Government corporation to achieve them, and authority within DOE for interim funding. This legislation rekindled industry interest in high-Btu gasification.

The first piece of legislation was Public Law 95-238, the Department of Energy Act of 1978--Civilian Applications, dated February 25, 1978, which authorized loan guarantees for alternative fuel demonstrations. This was followed by the establishment of the Assistant Secretary for Resource Applications within DOE to develop a commercialization strategy for alternative fuels.

Then in November 1979, Public Law 96-126 (DOE's 1980 appropriations) authorized an alternative fuels production program and set aside a $19 billion Energy Security Reserve to provide incentives for commercial production. This and later laws made $5.5 billion available to DOE, from which it offered a $2 billion loan guarantee to the Great Plains project.

This DOE effort became known as the interim or "fast start" program, because it paved the way for the keystone program established by the Energy Security Act of 1980 (Public Law 96-294, June 30). This act created the Synthetic Fuels Corporation, an independent Federal entity, to promote the production of synfuels from domestic resources. SFC's actions are to take place in two phases. In the first phase it can use the Energy Security Reserve 1/ to assist synthetic fuels projects that will produce the equivalent of 500,000 barrels of oil a day (about 1 quad a year) by 1987. While these are getting underway, SFC is to develop a strategy for producing the equivalent of 2 million barrels of of oil per day (4.2 quads per year) by 1992. This

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1/About $1 billion was devoted to "biomass" projects to produce fuel from renewable organic sources, such as agricultural crops, waste materials, etc., to be administered by DOE. Of the almost $18 billion remaining, SFC will have access to whatever is left when the DOE $5.5 billion interim program ends.

strategy is to be submitted for congressional approval by 1984, after which the Congress may authorize an additional $68 billion to meet the 1992 goal.

The sponsors of the Energy Security Act believed that because synthetic fuels projects were too costly and risky to attract sufficient capital from private financial institutions and investors, Government assistance was needed. The act contemplated that SFC's role would be that of a Government "banker." Authority for different types of assistance was granted: SFC could subsidize the price of the fuel produced, agree to purchase the fuel for Government use, guarantee loans provided by private lenders or make loans itself, enter "joint ventures" whereby it would share the project's costs and products, or finally buy out a sponsor's interest and lease the plant to an operator. Under certain conditions, SFC could even contract to build Government-owned plants.

The Energy Security Act also continued the interim program by authorizing DOE to carry on until the President could appoint the Corporation's board and declare it operational. This authority was given to the Assistant Secretary for Resource Applications. In particular, the act recognized the advanced state of high-Btu gasification plans by authorizing DOE, within 30 days of enactment, to solicit proposals for commercial-scale high-Btu coal gas plants.

However, DOE determined that Great Plains, which had already submitted an unsolicited proposal, was the only project ready to begin construction. Thus it made conditional commitments for loan guarantees of $250 million, then $1.5 billion, and finally $2 billion. Meanwhile, other projects revived and began preparing proposals for SFC.

Though the loan guarantee commitment gave Great Plains an important push, by itself it was insufficient to get construction underway. In 1975 American Natural Resources, the principal sponsor, had applied for Federal approval to charge the plant's cost to its customers. The application drew protests from the customers, who felt they should not have to fund a plant that would make only a small contribution to their supply at a very high price. To help defray the cost, American Natural Resources formed a sponsoring consortium with other gas companies. Finally, with DOE's $1.5 billion conditional commitment in 1981, the consortium reached an agreement with the ratepayers and the Federal Energy Regulatory Commission for the sale of the gas. Its apparent success in obtaining early financing while other proposals waited in the wings led to Great Plains' being heralded as the Nation's first commercial synthetic fuels venture.

COST AND NEED DICTATE A CAUTIOUS APPROACH

Despite the high interest in commercial high-Btu gasification, several obstacles to development remain. The capital costs

of the plants are huge, especially for some of the gas industry firms likely to be the prime developers. Also, the cost of gas produced is higher than that of alternatives and is likely to remain so over the near term. Lastly, high-Btu gas from coal will not soon be needed to meet demand. These factors all warn against a sweeping commitment to coal gasification.

Commercial plants require huge capital investments

Since no commercial high-Btu gas plants have ever been built in the United States, estimates of the cost to construct them--capital costs--are far from firm. In fact, to resolve the uncertainty of these estimates is one of the Government's chief reasons for supporting the first plants' construction. At any rate, they will clearly be expensive. Among the three commercial plant proposals we reviewed--Great Plains, WyCoalGas, and Tri-State--estimates ranged from $2.7 billion for a half-size plant to $7 billion for a full-size plant.

The most reliable of these estimates was the Great Plains estimate for a plant half the size of that originally proposed. It was developed through a detailed engineering study, including firm bids from component manufacturers, and the project has already broken ground. The Great Plains's sponsors are organizing a financial package totaling $2.7 billion--$2.0 billion for the plant proper and $700 million for contingencies and a connection to a main pipeline. The other two projects based their estimates on feasibility studies. WyCoalGas similarly estimated $2.7 billion for a half-size plant, while Tri-State estimated $7 billion for its full-size plant. The Tri-State project is rather different in that its products would be divided between high-Btu gas and a variety of liquid fuels.

All these estimates are stated in terms of actual or escalated dollars--what construction will actually cost as various stages are reached. For example, Tri-State officials estimate their plant will cost $3.5 billion in 1980 dollars, which will inflate to about $7 billion by the time the plant is completed in 1987. Direct comparisons among the projects' capital cost estimates would be somewhat meaningless. Besides differences in reliability of estimates, the projects vary greatly in size, technology, location, and myriad other factors.

Capital is, of course, money that must be spent in advance and then recovered slowly over the life of a plant--possibly 20 to 25 years. Most projects assume that 75 percent of capital will be acquired through long-term debt and 25 percent invested by the sponsors. Revenues from the plant must be adequate not only to recover capital, but also to pay lenders their interest and investors a fair return on the equity.

Despite the unreliability of estimates, it is clear that commercial-size gasification plants are hugely capital intensive. The large investment required has been a major obstacle to the construction of these plants.

Gas cost initially higher than alternatives

The large capital costs are the biggest factor in the cost of the high-Btu gas produced. As indicated earlier, the effects of natural gas price decontrol have not been assessed in this report. Excluding these effects, it is expected that at least for the first several years of plant operation, the gas will be more expensive than natural gas, which requires a much smaller capital investment. In the long run, though, sponsors believe coal gas probably will not increase in price as fast as conventional energy sources, once the plant is built.

As capital costs are difficult to pin down, so is the cost per unit of gas. Cost estimates can vary widely, even for the same proposed plant, depending on assumptions and calculation techniques used. Factors such as debt interest, equity return, coal cost, capital costs, plant lifespan, accounting method, and so on can shift costs dramatically.

As with capital estimates, the project with the best gas cost estimates is probably Great Plains. This project is the furthest along and has already received permission from the Federal Energy Regulatory Commission to sell its gas to pipelines at a pre-fixed price. Great Plains officials estimated an average cost of $13.45 per million Btu. However, their FERC-approved tariff does not provide for selling the gas at a price based on this cost. Rather, it fixed the price to reflect the gas' value, as measured by the cost of the most expensive substitute fuels. 1/ The base price was fixed at $6.75 per million Btu as of January 1, 1981, 2/ comparable to the price of recently discovered natural gas (deregulated by the Natural Gas Policy Act), though about 4 times the average price of all domestic natural gas. From then on, the price is to escalate at a rate consistent with inflation, but limited, once the plant begins operation, by increases in the cost of alternatives, such as high-priced domestic and imported natural gas and a close substitute, No. 2 fuel oil.

1/Economists call this the marginal cost. It is intended to represent what consumers would pay for the additional fuel they would use if the coal gas were not available.

2/Of course, the plant will not begin producing gas for several years.

Although prices and costs for high-Btu gas will not be accurately known until commercial-scale plants are built and operating, officials from all three commercial projects reviewed agree the gas will initially cost more than alternatives. They assert, however, that its cost will increase more slowly than the cost of alternatives. Roughly two-thirds of the cost, capital spent in the beginning of the project, will be "frozen" at the time of construction; only the remaining one-third, the operating cost, will be subject to later inflation or real price increases. Assuming other energy prices continue to rise as they did in the 1970s, high-Btu gas will eventually "cross over," or cost less than the alternatives.

The fluctuating prices of alternatives contribute to the uncertainty of planning gas plants. Tri-State officials point to the Wesco project as an example of how crossover could have worked. The project failed, according to a manager, for lack of Government support and because of difficulties in obtaining necessary land leases. However, had the Wesco plant been completed as planned in the mid-1970s, the gas would have cost an estimated $2.50 per million Btu. That would have been very expensive gas at that time but eminently reasonable now. On the other hand, as a Congressional Research Service official advised us, a plant built in 1950, when energy prices were not rising rapidly, would not have reached crossover until 1974, after its useful life had nearly run out.

Current need for high-Btu gas is minimal

Though ominous forecasts of rapidly declining natural gas supplies originally inspired project sponsors, the picture today is somewhat brighter. Natural gas is still a finite resource, but increased exploration has created some optimism.

Escalating prices for natural gas have caused an increase in drilling and exploration. Discoveries have been made at depths not attempted before and in new locations, although it is too early to determine their impact on gas reserves. In addition to new discoveries in the contiguous United States, quantities of natural gas are becoming available by pipeline from Alaska, Canada, and Mexico.

Thus, although the Great Plains sponsors started the project as a supply effort to alleviate a shortage of natural gas in their pipeline system, they and other sponsors feel the need is no longer so pressing. They reduced the plant's size from four modules to two and expanded the area served to reduce the impact of the capital investment. This also reduced the impact of the project's higher priced gas on individual customers because the volume of gas will now be divided among the customers of four pipeline companies. The sponsors still have the flexibility to increase the plant's output at a later date by adding additional modules.

Though natural gas may be sufficient in the near term, the long-term picture for gas supplies is still cloudy. Considerable uncertainty surrounds gas forecasts as they go further in the future. Most projections indicate that conventional natural gas from the contiguous United States will decline, and that the future gas supply picture contains a "wedge" of supplemental supplies including high-Btu gas from coal, on top of the declining conventional supply. Given the unpredictability of supply, demand, and other economic variables, no one can accurately forecast how much high-Btu gas will be needed and when.

LARGE EXPENDITURES LIE AHEAD

The Energy Security Act constituted a program of synthetic fuel production. Combined with the impetus towards large-scale demonstration plants gathered by the research, development, and demonstration program, the new commercialization program seemed to herald large new expenditures for high-Btu coal gasification, numbering in the billions. While the Government's expenditures under the Reagan Administration will be at a lessened pace, any commitment to high-Btu coal gasification will still be large.

After numerous pilot projects, the second generation had matured to the point that a large-scale demonstration became the next obvious step. A demonstration plant takes processes that have been proven technically in pilot plants and proves their economics and environmental acceptability at near commercial size. The demonstration step can be skipped, if the pilot plant is large enough to obtain the necessary information for commercialization. An alternative is to build a demonstration plant as a "module" that can be expanded to a commercial-size plant more or less by simply adding modules. 1/

In 1980, two candidates were vying for demonstration project funds under DOE's high-Btu gasification RD&D program. Their projected construction and operating costs, which the sponsors were supposed to split with DOE, ranged from $425 million to $636 million. DOE announced intentions to choose one. Under these circumstances the second-generation program seemed likely to spend more in the next 5 years than it had in the last 10.

But while the demonstration program's cost could be counted in hundreds of millions, funds committed under the commercial program could soon amount to billions. Besides the Great Plains

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1/A distinction is drawn between "size" and "scale." A demonstration module could be built using components of the same dimensions that would be found in a commercial plant; this would be a commercial-scale plant. A commerical-size plant would have sufficient capacity to be justified economically.

project and loan guarantee of $2 billion, six other coal gas projects have applied for SFC assistance.

NEW ADMINISTRATION ADVOCATING SHIFT IN DIRECTION

Though coal gasification has gathered considerable momentum, it seems to be running into difficulty. The change in administration has brought a new direction to the executive branch's policy. Believing that market forces, not the Government, will solve the Nation's energy problems, President Reagan took responsibilities for demonstration and commercialization away from DOE and left them to the Synthetic Fuels Corporation.

The new administration's view of energy research and development is that the Government should emphasize long-term, high-risk R&D with large potential payoffs, while leaving large demonstrations and commercial applications to private industry. Thus it halted DOE's plans to fund a second-generation demonstration plant, suggesting that these proposals might receive assistance from SFC.

Furthermore, the new administration in February 1981 abolished the office of the Assistant Secretary for Resource Applications. 1/ However, some of the activity continued and by August 1981, DOE had made preliminary commitments to one high-Btu coal gasification project and two oil shale projects. In September 1981 four SFC board members were confirmed by the Senate. Together with the Chairman, previously confirmed, the board can now begin setting policy. On February 9, 1982, the President declared the SFC to be operational.

PROGRAM DIRECTION UNCERTAIN

The second generation's long path of development, the recent drive toward commercialization of the first generation, the cloudy outlook for gas supplies, the large new expenditures on the horizon, and the new administration's redirection have brought high-Btu coal gasification to a crossroads. The Congress and the executive branch must consider several important issues before proceeding further.

First, now that the second generation has moved beyond R&D to the demonstration phase, DOE is preparing to move a third generation of processes down the same path. It is also supporting generic research applicable to various processes. On the other hand, it has dropped plans for environmental research on the

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1/The President and the Secretary of Energy have also gone on record as favoring the complete dismantling of DOE.

state of high-Btu gasification technology, is continued Government R&D support necessary? (See ch. 3.)

Second, the canceling of DOE's demonstration program means the second-generation processes will have to compete for SFC assistance against other attractive technologies. Will they be able to move forward, or has their long path of development come to an end? (See ch. 4.)

The first generation has been ready for commercialization for some time. Its chief obstacle has always been that the gas will be too costly to be marketable. Given the new administration's philosophy of letting market forces determine commercialization, plus the apparent adequacy of natural gas supplies for the near future, what benefits are there to Government support? If support is beneficial how can costs be kept to a minimum? (See ch. 4.)

Fourth, proposals for high-Btu gas plants offer an array of processes, coal types used, and product mixtures. Assuming some of these projects are to be supported, how might they be selected to give the greatest national benefit without overcommitting funds to one technology? (See ch. 4.)

CHAPTER 3

THE GOVERNMENT NEEDS TO BETTER FOCUS RESEARCH AND DEVELOPMENT

With the culmination of some programs, the elimination of others, and a radical change in administration philosophy, the Department of Energy needs to bring its research and development of high-Btu gasification into sharper focus. The overall second-generation RD&D program has been fragmented, protracted, and costly and had limited success. DOE also set out on a program for a third generation of technologies that seems not to require Government involvement at this time.

Further, DOE continues to be involved in research on materials and instruments. Much of this research can and should be done by the private sector in connection with their first plants or their own timetable for industrialization. On the other hand, necessary environmental research that was connected with the demonstration program fell by the wayside when that program was swept towards the Synthetic Fuels Corporation. This research is unlikely to proceed without DOE support.

Past DOE activities are entrenched and inhibit efforts to redirect the Department. If Government R&D spending is to be reduced while industry innovation is to continue, DOE needs to define overall criteria and define objectives and benefits by technology. It also needs to develop a planning process to conform activities to priorities.

FOCUS FOR GOVERNMENT R&D

Government funding of R&D is generally considered justifiable when it is clearly in the national interest and when the private sector is unwilling or unable to commit enough resources. Much more specific criteria, however, is needed to make decisions on the appropriateness of Government involvement in individual technologies and projects.

The prior administration was pursuing a vigorous R&D program to support a variety of energy alternatives. Coal gasification was part of an overall fossil energy R&D program, a broad spectrum of projects including various technologies at all stages of development.

The new administration, however, is working to change the R&D direction significantly. The new emphasis will be on long-term, high-risk projects with a potential for high payoffs. Major pilot plants are marked for termination as part of a withdrawal from near-term R&D. The new focus for the program, which stems from the overall change in R&D philosophy, is embodied in the following fossil energy R&D policy and strategy statement:

"The Government will concentrate on providing a sound technical base by focusing on longer range, high risk research and development. Government assistance will focus on energy options that are truly beyond the capacity of private industry and thus do not pre-empt private initiative or benefit individual firms. Where the risk is sufficiently high and the promise sufficiently great, a primary Government role may be justified. Once the conceptual hurdles have been surmounted and the commercial benefits are evident, the final scale-up and development of a new technology will be the responsibility of industry."

DOE, however, has not defined "long term," high risk," nor "high pay off." In our August 17, 1981, report entitled, "Unresolved Issues Resulting from Changes in DOE's Synthetic Fuels Commercialization Program," EMD-81-128, we recommended that these terms be defined. We stated that long-term could be defined in years to commercialization and remaining R&D assessed in light of that criteria. We suggested that high-payoff criteria could include a range of production cost savings or greater efficiencies over commercially available technologies. Risk criteria could include scale-up and other technological risks, environmental risks, and economic risks to industry to perform the R&D.

In answer to our August 17, 1981, report, DOE stated they recognized that the phases "long term," "high risk," and "high payoff" were not precise delineators that could be mechanically used to determine which projects fell within the scope of its R&D program. However, the Department did not intend to develop specific definitions since they felt that the very nature of the project selection process for R&D funding demanded a strong degree of flexibility. DOE felt that the choice of which projects were long-term, high risk, and high-payoff would be best left to R&D program managers who have technical perspective to make the necessary judgements concerning the benefits of projects and are capable of determining the appropriateness of Federal funding by following the guidelines established by the Secretary and the appropriate Assistant Secretary.

We recognize there has to be some flexibility in determining R&D project funding. We also recognize there can be no identical boundary line for all technologies given the differences in markets, competitive economics, and the prospects for significant R&D improvements. However, in order to provide some meaningful focus to R&D, there has to be some defined criteria, and if the criteria is to include "long term," "high risk," and "high payoff" these terms should be defined.

CERTAIN R&D COULD BE PERFORMED BY INDUSTRY

DOE is supporting certain research in high-Btu gasification that apparently could be left to industry. Of $64 million allocated to surface gasification in DOE's revised 1982 budget, a substantial portion is dedicated to research on high-Btu technology. Included was at least $11 million in process R&D dedicated to second and third generation high-Btu processes, and an indistinguishable portion of generic research on materials and instrumentation control which would also benefit high-Btu processes. Much of this appears to be inconsistent with the administration's philosophy and it is not clear why the Government is continuing support.

Need for further process research is unclear

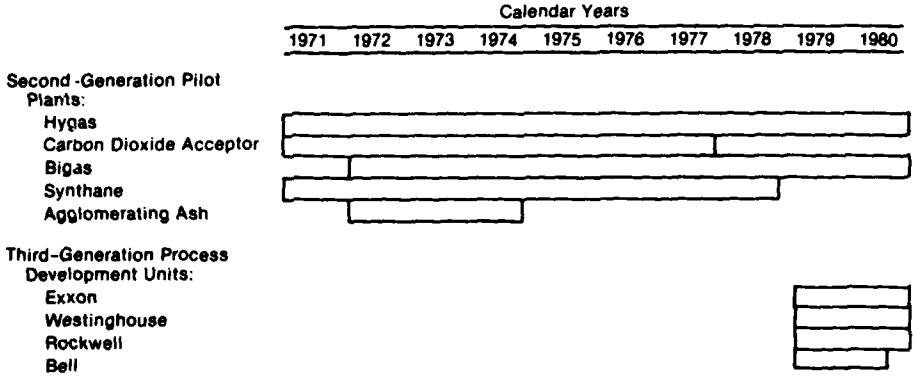
After a protracted, costly program, DOE has brought the second generation of processes to the brink of commercial readiness, but the results have not been good enough to overcome marketing and economic problems and ensure commercial use of even the best process. Now DOE is focusing on third-generation processes, even though those identified to date appear to offer only slight advantages, some might only equal second-generation economics, and some companies seem willing to develop them without Federal help.

The objective of second-generation process R&D was to develop more efficient high-Btu gasification processes capable of using a wide range of coals, including the high-sulfur, caking coals found in the Eastern United States. To that end, the Government, separately and through a joint program with the American Gas Association and later the Gas Research Institute, began in 1971 to fund advanced gasifier projects through the pilot plant or process development stage.

The joint program was expected to last 4 years and cost $120 million, including $10 million for a demonstration plant design to use the best process. Ten years and over $300 million later, the second-generation program had run its course and a group of third-generation processes were receiving support.

The following table shows the years under the joint program during which each second-generation gasifier received Government funds through the pilot plant stage and each third-generation gasifier through the process development unit stage. It identifies the major high-Btu coal gasification processes and highlights the shift of the research under the joint program to more advanced high-Btu coal gasification processes. DOE and GRI officials advised us that while Government and GRI participation in the joint program indicated concurrence with that program's objectives the Government support was not always

PREDEMONSTRATION TIMETABLE FOR SECOND- AND THIRD-GENERATION GASIFIER CONSTRUCTION AND OPERATION



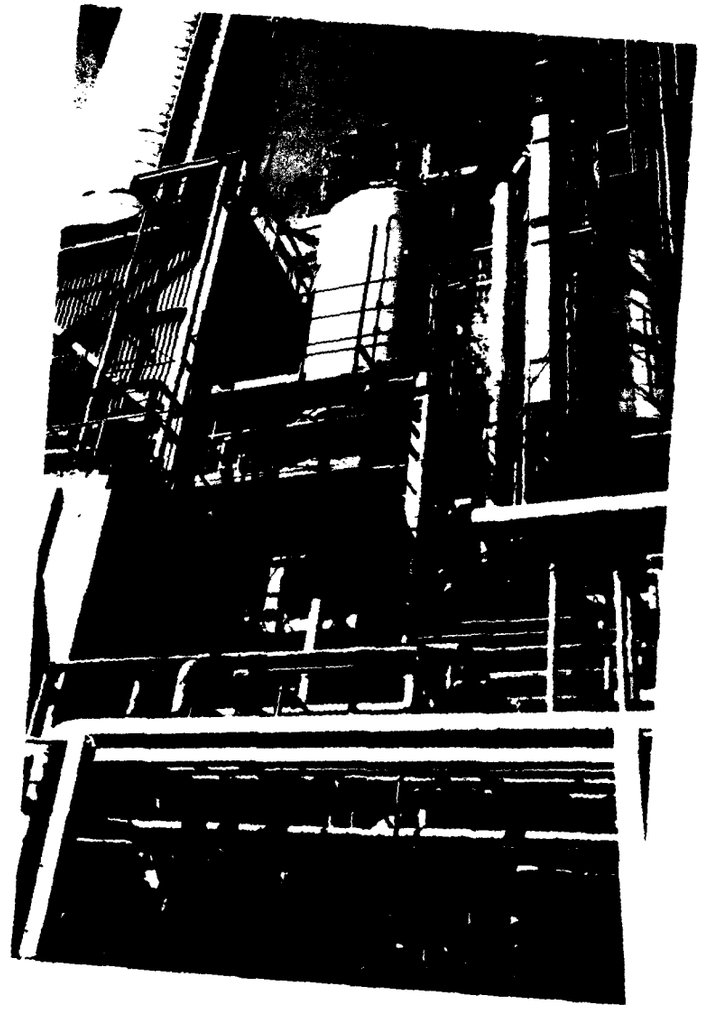
limited to the same time frames or objectives. For example, some of the processes received Government's support prior to the start of the joint program and the Government support has in some instances continued after joint program funding ended. Bigas is one such process. Also, the Westinghouse process as shown above came under support of the joint programs in January 1979 with the specific objective of developing high-Btu gas. The Government provided earlier support to the Westinghouse process for low- and medium- Btu development directed at industrial applications. DOE officials advised that the Westinghouse process should be considered a third - generation process only with respect to its potential high-Btu applications and joint program fundings.

Second-generation processes still at a disadvantage

The net result of the second-generation pilot plant program has been to demonstrate that one process out of the five supported, Hygas, has the potential for reducing investment and product gas costs in the 12 to 20 percent range over first-generation processes. Despite the success of the Hygas process, it seems less likely than the first-generation Lurgi process to move to early commercial demonstration. The outlook for commercializing the other processes tested is even less certain.

The Hygas process, with Government support ending in 1980, is the only second-generation process to have apparently achieved the program's goal. (See p. 29.) The second-generation program set out to produce gas at least 20 percent cheaper than the first generation. Preliminary cost comparisons indicate that Hygas will not meet the goal using western coal and just meet it using eastern coal. DOE cost comparisons state that the potential error in the estimates equals the projected cost advantages on eastern coal and the cost studies will not be the only factors considered.

In the forseeable future and regardless of technology, commercial plants using western coal will have an inherent cost advantage over plants using eastern coal because of the lower cost of western coal. For example, preliminary second generation studies show that a Lurgi plant using western coal is more attractive than a Hygas plant using eastern coal. In weighing the advantages of a Hygas plant against a Lurgi plant, project sponsors also have to consider both technical uncertainties. The Lurgi process has a long history of proven success, has been improved over the years, and has much better documentation on costs. At a time when the competitiveness of any form of coal gas is uncertain, potential sponsors who are not tied to a particular coal are very likely to choose Lurgi with a western coal for their first plants.



CLOSEUP PHOTOGRAPH OF A SEGMENT
OF THE HYGAS PILOT PLANT

The Government supported four other second-generation processes that have been less successful. One was technically proven on western coal but showed no economic advantage over Lurgi. Two others were dropped before they were proven. Finally, the Bigas plant, which suffered two fires in 5 years, overcame related technical and mechanical problems, and operated successfully in fiscal year 1981. In fiscal year 1982, DOE planned to complete its evaluation, terminate operations, and determine what should be done with the plant. One option being considered was the feasibility of turning the plant into a general test facility for coal gasification.

While DOE was supporting these processes, industry was working independently on other second-generation processes. Two of these had been sponsored for demostration plants. (See pp. 53 to 54.) Hygas had also received demonstration plant funds from DOE, but without firm industrial sponsorship. Thus the privately developed processes seemed more likely to see commercial use.

Questionable need for Government involvement in current third-generation processes

The need for continued Government support for R&D on third-generation high-Btu gas processes currently being funded appears questionable. Of four processes assisted under the joint program, two appear to be moving forward independently, one appears to be phasing out, and one was dropped. The process development tests show that the estimated product costs of these third-generation technologies fall substantially below the joint program objective of bettering first-generation technology by 25 percent. At most, the third-generation processes may equal the estimated cost of the second-generation Hygas process.

The joint program's remaining two processes, developed by Exxon and Westinghouse, proved their technical feasibility at the process development unit stage. They are ready to be developed and tested at a large scale. However, both appear able to move forward without further Government assistance. Exxon is willing to build its own pilot plant, while Westinghouse appears ready to prove its process in commercial applications other than high-Btu gasification.

Technically, the Exxon process was generally viewed by industry and Government officials as the last word in high-Btu gasification. Coal can be converted to high-Btu gas right in the gasifier in a single step. Other technical advantages include a potentially higher thermal efficiency than other gasifiers. While preliminary cost projections show that the Exxon process compares favorably with Lurgi on eastern coal, they do not show it outperforming the second-generation Hygas process. Exxon has apparently improved the design but the changes are largely proprietary and have not yet been demonstrated. Joint program estimates of the impact of these changes

indicate that economic performance is still behind Hygas. DOE officials believe that Exxon work at a larger scale will significantly improve the economics.

When the Exxon process was first included in the joint program, Exxon was uninterested in making a large investment to commercialize the process in the United States. However, in 1980, the company announced it was planning to build a pilot plant in The Netherlands and pick up the total cost of around $500 million itself. This pilot plant is to be large enough to provide design data for a commercial-scale plant. About $150 million of the $500 million would be spent at the process development unit, developed in the United States under the joint program, to assist in the design and operation of the pilot plant.

Originally, DOE envisioned supporting the pilot plant, but Exxon's announcement clearly makes that unnecessary. DOE officials were faced with deciding whether to continue supporting the concept through partial funding of the process development unit operations or withdraw from the project entirely. DOE chose to continue, although details of the program still have to be negotiated with Exxon and GRI. The new administration's budget request for fiscal year 1982 contains several million dollars for the project, and DOE officials expect joint support to continue for 8 years. The total support was estimated at about $30 million, or only 6 percent of Exxon's estimated total funding.

DOE's aim in the negotiations is to gain access to technical information, to achieve testing of American coal, to protect the Government's share of royalties, and to ensure the technology's availability for commercial use in the United States. The principal right DOE had obtained in return for past support was a technology transfer package related to the later aim. What added information the Government gets will depend on what funds it provides and on future negotiations.

However, it is unclear why the Government should provide any added funds. Its main objective of bringing the Exxon process up to commercial readiness can apparently be accomplished from this point without Government funds. Also, the future of high-Btu coal gasification in this country does not depend on the Exxon process. Finally, neither DOE nor GRI is likely to gain much more in future negotiations because they are offering small contributions and Exxon can proceed without them.

The other third-generation process moving forward is Westinghouse, which may avoid the pilot stage altogether. DOE proposed spending $3.5 million in fiscal year 1982 to complete the evaluation of the process development unit's results. DOE is also considering using the facility in support of any demonstrations or commercial ventures industry proposes.

SFC has received three proposals for commercial plants producing medium-Btu gas with the Westinghouse process. The gas in these projects would be used for industrial fuel or power generation. Thus, the Westinghouse process could move forward without a Government-assisted pilot plant and with industry funding the process development unit if that is needed. Once the process is proven for medium-Btu gas applications, the move to high-Btu gas production would require only a relatively small scaleup and the addition of methanation--a step already used with first-generation technologies.

What's next?

Indications are that DOE does not intend to quit after the third generation. In its revised 1982 budget request for advanced gasification research, DOE stated, "Gasification processes offering increased efficiency, simplicity of reactor design, or increased reliability are of continued interest to the program."

Processes to gasify a broad range of coals are now ready for commercial use. New processes that promise small increases in efficiency, such as those once promised by the second- and third-generation processes, would seem better left to private development, if they are to be developed at all. A GRI official explained that if a process does not exhibit a definite economic advantage over existing processes at an early stage in development, it is not worth pursuing. As new processes come closer to realization, the anticipated economics usually diminish.

Some generic research appears inconsistent with new R&D philosophy

Besides work on specific processes, DOE supports generic research applicable to more than one process. Some of this research would seem inconsistent with a focus on risky high-payoff research. For example, in 1976 ERDA began a program to assure commercial availability of instruments and control systems for future large-scale fossil energy processes.

From the start, program budgets have been funded at minimal levels varying from several hundred thousands to around a million dollars per year for all of fossil energy. However, the Carter administration's 1982 budget asked for a large increase. The overall program reached $2.2 million, and an additional $2.3 million was allocated to instrument and control research for surface gasification.

The fossil energy portion of DOE's budget for generic research did not change with the switch in administration. The amounts and narrative in the Reagan administration's 1982 budget in March 1981 were identical with the Carter administration's budget in January 1981. This was surprising, given the wide divergence in the two administrations' philosophies. The previous

administration tried to increase the applied generic research in 1982 to speed commercialization. In contrast the new administration espouses severely limited Government involvement in commercial activities

At a January 1980 instrumentation and control workshop, DOE obtained opinions on the technical needs, barriers to technology transfer, and the potential for improved communications in the area. Developers highlighted as major barriers their fears that patent rights and trade secrets would be lost through Government involvement. They also expressed a lack of interest in new Government-sponsored work if it did not offer retention of patent rights as an incentive. Discussed, but not fully explored, was the question of who should develop instruments. The consensus was that companies responsible for large projects would do the major work. Other helpful instruments could be developed by specialty companies if a large market existed. In the absence of such a market, DOE could fund the work through grants and waive the patent rights.

In light of these opinions, the applied research for instruments and control does not seem to fit under the new administration's focus on long-term, high-risk, high-payoff research. The need for a higher Government allocation to applied surface gasification research, when the Government is emphasizing the industry's responsibilities for such near-term commercialization, is dubious. Besides the question of responsibility, an ERDA sponsored study 1/ reported that over 90 percent of the instruments being used in coal conversion systems are conventional instruments which function satisfactorily and will scale up.

Similarly, the 1982 budget contains a $2.3 million project to seek better construction materials for gasifiers. GRI typically sets a 10-percent improvement in reliability, efficiency, or cost as a minimum objective for such projects.

In discussing the need for Governmental funding, program personnel tended to justify the research on the basis that industry had no current economic or market incentive for such development. Implied but undefined was the need for large amounts of improved equipment at some future time. Also, undefined was the expected Governmental or national payoff's from the current funding of the research.

Continued need for environmental research

High-Btu coal gasification faces an uncertain regulatory future because it is an emerging industry meeting emerging regulations. On one hand, data is lacking on the environmental

1/The state-of-the art study was conducted by Argonne National Laboratory (ANL-76-4, January 1976).

effects of coal gasification; on the other, standards and guidance are lacking on how these effects must be limited. Though DOE intended to address these problems in connection with the first demonstration and commercial plants, these plans have been dropped.

DOE and the Environmental Protection Agency have distinct statutory responsibilities for environmental studies of emerging energy technologies; EPA sets environmental protection standards and DOE promotes development and commercialization in an environmentally acceptable way. While the programs of the two agencies are coordinated and integrated, each has its general sphere of influence. DOE seeks to measure the environmental effects of new technologies and develop ways to control them, while EPA and other agencies concentrate on problems associated with the electric power industry. DOE has done most of the environmental research in the emerging coal gasification technologies.

EPA is working out a schedule with DOE for publishing enforceable standards for high-Btu coal gasification, but the standards will not be published for several years. In the interim, EPA plans to issue pollution control technical manuals, which will not be legally binding but will describe pollutants, environmental control alternatives, and costs. The pollution control manuals for high-Btu coal gasification were not expected until late fiscal year 1982. Meanwhile, EPA officials were not ready to draw conclusions or make policy statements regarding the environmental acceptability of synthetic fuels in general or high-Btu gasification in particular.

Government efforts to collect environmental data have so far met with limited success. The pilot plants did not lend themselves to accurate projection of commercial plant emissions. Commercial plants abroad either have not had to meet stringent environmental standards like those likely to be imposed in the United States or have not cooperated in supplying information.

Nevertheless, some conclusions could be drawn. DOE officials had identified significant environmental, health, and safety problems, including solids disposal, effects on workers and public health, liquids disposal, and site-related limitations impeding development of high-Btu coal gasification technology. They found, however, no environmental reason for not going forward, as long as the necessary research continued. Studies indicated that resolving the issues could cost tens of millions of dollars and take up to 8 years.

In June 1980, DOE's Assistant Secretary for the Environment published a broad study on synthetic fuels and the environment. The study analyzed environmental and regulatory obstacles to an accelerated synthetic fuels development program, and concluded that they could be overcome by a two-stage effort. The initial stage would emphasize applied research and development, including

environmental research, and the second would accelerate the deployment of the technologies most ready for economic operations within environmental strictures.

Similarly, Argonne National Laboratory, in conjunction with environmental pilot plant work, performed under a DOE contract, recognized a need for a detailed and comprehensive assessment of large-scale coal gasification technology. The first step was to develop environmental program plans to be conducted before, during, and for some period after the operation of demonstration or early commercial gasification plants.

In accordance with this approach, DOE officials were moving toward plans for both the Conoco and ICGG demonstration projects. DOE environmental officials had also examined the need for the research on the first commercial high-Btu gasification plant, the Great Plains project, and had drafted a research plan for that project. They concluded that the Great Plains research program should go beyond mere regulatory compliance to reliable and comprehensive assessments and control of environmental problems. The rationale was to improve the data base so it could be projected for a mature synthetic fuels industry and to assess environmental effects beyond the levels required by current compliance standards.

While plans were not fully defined, they were proceeding under the premise that DOE would fund any research program that went beyond the commercial sponsors' responsibility to comply with guidelines or regulations. This was consistent with DOE and EPA's relationship and with the views of the commercial sponsors and the officials of the Synthetic Fuels Corporation that they would both be concerned with compliance matters only. DOE environmental officials estimated that this research program would cost the Government about $3-4 million per year for 3 years, or $9-12 million altogether, for the first large demonstration or commercial high-Btu coal gasification facilities.

When the new administration decided to eliminate the demonstration projects, it also requested rescission of related environmental work for 1981. The 1982 DOE budget contains no environmental research funding related to specific demonstration or commercial high-Btu projects.

Although environmental research continues to be important to commercialization of high-Btu gasification, DOE seems to be shrugging off its responsibility. When its Office of Energy Research asked what role it would have in emerging technologies and projects that DOE no longer funded, the administration replied that this was a budget matter. The rescissions for environmental research on the demonstration plants called it industry's responsibility. When we discussed the policy issue with an OMB official, he questioned the need for the Government to do the research and indicated that if needed it was EPA's area of responsibility.

EPA officials said they had no plans to fund the research which they acknowledged was needed. Given present budgeting constraints, they could see little potential for changes in the present EPA plans.

While DOE has terminated its high-Btu demonstration projects, it is not through with considering the environmental effects of large scale projects. For example, the Department was involved in the negotiations on the environmental monitoring plan for the Great Plains project. However, these negotiations were not complete and the results remained uncertain. In addition, DOE will have continuing consulting responsibilities on the environmental monitoring plans if other large scale high-Btu projects are considered for selection by SFC.

COHERENT PLANNING NEEDED TO CONFORM ACTIVITIES TO PRIORITIES

Coherent planning can help eliminate discrepancies between DOE's activities on the one hand and the administration's focus and national priorities on the other. DOE needs an integrated, long-range plan based on a clear definition of where its responsibilities for R&D end and where industry takes over. In our report entitled "Unresolved Issues Resulting from Changes in DOE's Synthetic Fuels Commercializations," EMD-81-128, dated August 17, 1981, we recognized that a review of R&D based on well-defined criteria could assist the Congress in assuring that limited Federal funds are being applied consistently to meet the Government objectives.

Integrated planning

DOE has been working on a long-range plan for fossil energy R&D for some time. A longstanding objective has been to formulate a clearly visible and well-supported basis for establishing priorities, but so far DOE has fallen short. The change in administrations and a fundamental change in the direction of the Federal Government's research and development role make this objective imperative if Federal expenditures are to be reduced while technological innovation by industry continues.

DOE could improve its planning by taking a cue from its sometime partner in the field, the Gas Research Institute, even though its responsibilities and the magnitude of its activities differ considerably. In general, GRI's planning process tends to surface policy issues for high-level review and devotes considerable attention to detailing strategies.

In 1977 DOE's predecessor, ERDA, had been involved with numerous technologies and was setting priorities based on a market-oriented strategy. DOE continued to improve program plans in 1978, trying to establish fully visible and fully supported

priorities. Also, in 1979 the Office of Fossil Energy began reexamining its overall program to address R&D needs associated with technologies ready for immediate commercial deployment and to better focus the program on emerging technologies that could contribute to reducing imports in the late 1980s. This focus, which was moving towards more pragmatic near-term research under the prior administration, was abruptly redirected under the new administration to long-term, high-risk, potentially high-payoff research.

The period 1977-80 was one of considerable turmoil. When we tried to follow the program changes under the prior administration, we were told the plans were still being updated, revised, etc. However, review of available documents disclosed only nominal changes in the direction of high-Btu coal gasification. For example, the research into second- and third-generation processes would still run its course, as would the demonstration program, and these directions and the related research had generally been established long before the 1979 examination. What was new was an increase in generic research, including that in the environmental area. The new administration eliminated the highly visible demonstration efforts and related environmental research but did not review other research, nor establish a new plan, new priorities, etc. The actions taken were swift and dramatic; however, like those of the previous administration, they illustrated how programs have a life independent of policies.

The new administration has come out with some early guidelines for its fossil energy R&D policy and strategy; however, the guidelines are as broad as those of the prior administration. For example, process-specific research for enhanced oil recovery, coal liquefaction, oil shale, and direct use of coal in lieu of oil are of the highest priority. Supplemental gas supplies and coal gasification fall in the second priority. There are four categories in all, and the guidelines say they are not all-inclusive and go on to refer to other applied and generic research. The guidelines also state that processes will continue to be developed through the pilot plant level and mention special programs, such as Exxon's. However, what emerges is an umbrella description that covers most of what was in the prior administration's budget, except for the demonstration programs.

Contrasts between DOE and GRI planning

Under past DOE planning, large, costly projects have attracted attention from senior DOE management and congressional committees. Also, DOE divisions and offices interact and DOE interacts with OMB as the fossil energy budget is assembled within overall funding and program guidelines. While programs and projects must be justified, no overall system integrates priorities, strategies, and activities.

The GRI planning process exemplifies a sophisticated system that does integrate priorities, strategies, and activities. Under

its FERC mandate, GRI is to establish objectives, assess benefits, set priorities, and coordinate R&D activities. The center of industry's coal gasification research funding, GRI has grown rapidly. In 1979, its total budget was about $40 million; in 1980 that increased to $58 million. In September 1980, FERC approved a GRI program for 1981 at a level of about $81 million. GRI expects to spend about $12 million specifically on coal gasification research in 1981, $7 million in 1982, and amounts increasing to $15 million a year by 1986.

GRI formulates policies and objectives to establish the major emphasis of its program. Policies evolve from outside events or GRI's own successes and failures. GRI then builds the objectives around the policy framework, specifying the problems to be addressed and the type of R&D to be done.

As its next step, GRI establishes a three-tiered hierarchy of objectives--overall, strategic, and tactical. Overall objectives are more supply options, more efficient utilization, and enhanced service. Three strategic objectives are set for each overall objective and consist of broad courses of action for the near-term (the first 5 years), the middle-term (the 6th year through the 20th), and the long-term (beyond the 20th). Within the overall and strategic objectives, tactical objectives for project areas describe a specific, desired result in terms of efficiency, cost, output, and completion dates, and these are addressed by project areas.

GRI goes into project area objectives in sufficient detail to provide a basis for measuring risks, payoffs, and priorities. To illustrate, GRI's fiscal year 1981 budget disclosed that the objective of the advanced coal gasification project area, which included a materials project, was to improve existing gasification processes by at least 10 percent in reliability, efficiency, or cost. Buried in DOE's fiscal year 1982 budget is also a materials project, costing $2.3 million. However, DOE officials had not come up with detailed, quantifiable project area objectives like GRI's. These kinds of objectives will undoubtedly aid in overall DOE planning.

Each project is appraised and subject to as many as seven criteria. GRI then sets priorities for project areas considering the appraisal results and the relative weights of strategic objectives and criteria. Project areas are also assessed at four GRI funding levels--no funds, current funding, minimum funding, and accelerated funding. Thus the difference in benefits from one level to the next is evident.

GRI develops its proposed R&D program through this process over a 15-month cycle. Input to items like objectives, criteria, and project area ranking comes not only from advisory boards and top management but also from line directors responsible for project areas. In the end, GRI's system relates a project area to all levels of objectives, sets priorities vis-a-vis other areas, and gives anticipated times for obtaining benefits.

DOE's planning process lacks this sophistication and integration. The rationale used in the planning process is unclear. This problem was established in our 1978 and 1980 reviews of fossil energy research, 1/ in criticism by others 2/, and in our efforts to understand the high-Btu gasification program. Meaningful information and documentation on the objectives for the demonstration program and the generic and environmental research program and how DOE was integrating these efforts were not readily available.

In contrast, GRI showed a much clearer sense of direction and integration. In 1979 and 1980 GRI questioned whether it should assist development of even more advanced processes at the predemonstration level or if it should instead support demonstration plants. GRI recognizes that the primary coal gasification problems were not a lack of technology but rather difficulties in regulating, financing, and marketing.

On the basis of this recognition, GRI decided to (1) avoid direct funding of demonstration plants, (2) support pilot plants only for novel processes with exceptional promise, and (3) assist the technology through selected generic research. Rather than deemphasize the significance of coal gasification, these actions recognized that the technology was mature. Most importantly, the role of GRI was clearly visible for others to consider.

Need to define boundaries of Government involvement

While GRI shaped its funding role in part on DOE's direction, DOE now needs to independently determine what distinct role is left to the Government. DOE apparently is phasing out big pilot plants and eliminating demonstration plants from its repertoire, but it has not defined how far it should go up the scale of development. DOE officials acknowledge that the terms for plant scale--pilot, demonstration, and so on--are relative. Process development units are not unlike pilot plants, and DOE distinguishes them arbitrarily by a boundary of 25 tons of coal consumption per day.

1/"Fossil Energy Research, Development, and Demonstration: Opportunities for Change," EMD-78-57, September 18, 1978; and "Need for a System to Establish Priorities Among Fossil Energy Technologies," EMD-80-65, April 8, 1980.

2/See EPA 600/9-80-008, EPA's January 1980 report to the Congress on the implementation of the Federal Nonnuclear Energy Research and Development Act of 1974. For example, "* * * the public * * * has little knowledge of how the Department of Energy (DOE) plans and manages research, development, and demonstration (RD&D) for nonnuclear technologies."

The Westinghouse process development unit, for example, has a capacity of only 14 tons per day. Exxon's proposed European plant is a pilot, since it will consume about 100 tons per day of coal. Yet, both processes are expected to make the transition to demonstration and commercial scale, respectively, from these plants. The Conoco and ICGG demonstration plants, which were also to pave the way for commercialization, were to use 1,250 to 2,200 tons per day respectively. Full-scale commercial modules of these latter processes would use 9,300 to 8,700 tons per day.

The terms of scale then, are no guide to DOE's role. As an alternative, one Department official reasoned that the cutoff for DOE support should be the point where the technical concept is proven. However, he stated that this proof might also occur at various scales.

Apart from the new administration's action to eliminate the big pilot plants and demonstration plants, there is the general guidance to emphasize "long-term, high-risk, and potentially high-payoff" R&D. However, there has been no detailed guidance on how these criteria will be applied to relatively mature technologies like high-Btu coal gasification or specific research projects in such a technology. Under the prior administration's planning, timeline terminology such as "near-term" and "long-term" was used; however, the terms were not well defined and individual project areas were generally assigned a priority consistent with that assigned to the overall technology. Here again, the planning concepts employed by GRI serve to contrast the differences between the processes.

For example, GRI not only defines near-, middle-, and long-term research but also distinguishes between benefit periods. A GRI official advised us that most of GRI's coal gasification research would be completed in the near-term (the next 5 years) but that the benefits would occur in the mid-term (up to the year 2000) when more significant deployment of commercial plants could be expected.

Unless the boundaries of Government involvement are defined, not only will some projects receive unwarranted funding, but the administration's drift away from near-term reseach may mean trouble for others. If the existing DOE-assisted projects in coal gasification R&D were arrayed starting with near-term commercial applications down to the furthest term, the riskiest ones, projects in the middle of the array would have an uncertain future. They may not be picked up by either industry or Government because of opposing viewpoints. Industry would approach the array starting with the nearest term, least risky projects, while the Government, under the new administration's philosophy, would approach from the other side. Thus a project might not be funded simply because it falls into a gap between industry and Government interest. The purpose of Government R&D is to assist a technology until its merits for commercialization can be judged. Exactly where industry and Government should meet on the R&D array varies,

since risk, timeliness, and payoff depend not only on technical factors but also on the market. The second-generation demonstration projects are a case in point. Industry sponsors stated that their project's chances of being developed without Federal support appear very doubtful.

CONCLUSIONS

The Department of Energy continues to be involved in research and development which apparently could be left to industry in connection with its first plants or its own timetable for industrialization. Meanwhile, the Department has reduced environmental research beyond what industry will have to do to comply with regulations.

We could not estimate the amount of near-term research funding that can be trimmed from DOE's budget because the budget does not sufficiently identify the funds devoted to each project and each technology. DOE must first define what it meant by "long-term," "high-risk," "high-payoff" research as part of its funding criteria. As we stated in our August 17, 1981, report entitled "Unresolved Issues Resulting from Changes in DOE's Synthetic Fuels Commercialization Programs," EMD-81-128, long-term could be defined in years to commercialization and remaining R&D assessed in light of that criteria. High-payoff criteria could include a range of production cost savings or greater efficiencies over commercially available technologies. Risk criteria could include scale-up and other technological risks, environmental risks, and economic risks to industry to perform the R&D. Also, the funding of some projects is part of a continuum that is not limited to 1 year, and DOE must decide how to terminate these projects in the most cost-effective manner.

Until DOE defines its funding criteria and applies them to potential projects as part of an integrated planning process, the less visible research planned as supportive to near-term projects under the prior administration will continue under the current administration. The Government will fund research and development that the private sector can and should fund.

RECOMMENDATIONS

We recommend that the Secretary of Energy

--establish a plan to guide future support of high-Btu coal gasification energy research and development. The plan should be based on clear policy objectives and defined criteria which will set the general limits of Government support in the context of overall energy research and development. Also, the plan should recognize research that is more appropriately funded by industry, and include essential environmental research that is beyond the responsibility of industry.

CHAPTER 4

COMMERCIAL DEMONSTRATIONS ARE UNLIKELY WITHOUT GOVERNMENT SUPPORT

Commercial-scale demonstrations of high-Btu coal gasification technology would resolve uncertainties impeding the development of one of the few commercially ready synthetic fuel technologies. Such demonstrations are unlikely without Government support, because the first plants will be too risky to attract sufficient capital. The Synthetic Fuels Corporation represents a unique avenue for advancing both first- and second-generation demonstrations and as such controls the technology's fate, at least in the near future. By supporting plants of limited size but commercial scale, testing diverse processes, SFC might advance this technology and the related technology of indirect coal liquefaction while minimizing its commitment of funds.

COMMERCIAL DEMONSTRATIONS WOULD BENEFIT THE NATION

Plants of sufficient size to resolve doubts about the technology's commercial economics and performance and to produce marketable quantities of high-Btu coal gas would benefit the Nation in several ways. They would demonstrate the viability of an apparently clean, efficient, environmentally acceptable, and technically ready way of using coal and stretch the long-term availability of natural gas. At the same time, they could produce significant quantities of fuel which could replace imported oil and assist the Synthetic Fuels Corporation in meeting its production goals.

High-Btu gasification one of few technologies ready

Among the technologies for producing synthetic fuels, high-Btu gasification is one of the few ready for large-scale plants. Basically, the "big three" synthetic fuels are coal gasification, indirect coal liquefaction, and shale oil extraction. These processes have repeatedly surfaced as having near-term potential.

Actions by DOE and the Congress have recognized that high-Btu gasification is near term. In 1978, a DOE special commercialization committee identified high-Btu gasification as one of the technologies with the greatest potential to market products in the near future. In the Energy Security Act which authorized SFC's formation, the Congress specifically granted DOE authority to solicit proposals for high-Btu gas plants before the Corporation was operational. This technology was the only one the act singled out for immediate attention. Under the interim program, DOE has

negotiated with only three construction proposals, two for shale oil and one for high-Btu gas.

Also, coal gasification, indirect liquefaction, and shale oil have consistently shown up as the primary synthetic fuels in very broad DOE and SFC solicitations. Under DOE's solicitations in 1980 for feasibility studies and cooperative agreements, these three technologies took the vast majority of awards for synthetic fuels. For example, under the first solicitation, the 3 received 23 of 26 synthetic fuel feasibility studies and 93 percent of the funds. Indirect liquefaction and high-Btu gasification accounted for all the synthetic fuel cooperative agreements. High-Btu gasification won a third of the approximately $120 million awarded to synthetic fuels under both types of assistance. SFC's broad solicitation for commercial synthetic fuel projects had similar results. Of the 63 responses to SFC, 42 were for oil shale, coal gasification, or indirect liquefaction.

The coal gasification proposals included both high- and medium-Btu gas. High-Btu gas was the principal product in six proposals, while medium-Btu gas, useful for generating electricity or plant fuel, was the principal product in nine proposals. The six high-Btu coal gasification projects, however, had a much higher total production capability than the nine medium-Btu projects.

Benefits of SFC-sponsored demonstrations

As a commercially ready technology, high-Btu gasification is a strong candidate for SFC assistance. Moreover, with DOE's commercialization and demonstration programs abolished, SFC is the only remaining Federal vehicle for further commercial demonstrations. This situation is consistent with the new administration's philosophy that private industry should set the pace of commercial synthetic fuels development, with Government help limited to that provided by the Synthetic Fuels Corporation. Making the Synthetic Fuels Corporation the vehicle is also fitting because these commercial demonstrations will benefit the Nation with both production and information, the twin objectives of SFC.

The production goals of the Synthetic Fuels Corporation are the more visible ones and these goals generally bring to mind the need to reduce oil imports and not the production and information benefits of a substitute for natural gas. Nevertheless, synthetic gas does have the potential of displacing imported oil. For example, gas can replace oil used in powerplants and industrial markets.

The legislative debate leading up to the creation of the Synthetic Fuels Corporation was long and replete with the need to gather information about the commercial and technological feasibility of a large-scale synthetic fuel program, concerns over

environmental efforts under a crash program and the technological and economic feasibility of reaching specific production goals. To resolve the debate and assuage opposition, the Synthetic Fuels Corporation program was established as a two-phased approach. In the first phase the corporation will have about $18 billion through 1984 to provide various types of financial incentives to private sector sponsors of commercial synthetic fuel projects. In the second phase the corporation will submit comprehensive strategy for further synthetic fuel development of the Congress. Thus after extended and careful deliberation, the Congress was able to take steps to deal with the energy crisis from both an informational and production view.

Consistent with the tentativeness implicit in the first phase, much valuable information can be obtained from the initial high-Btu commercial demonstration plants. Information, in fact, becomes the key benefit because before the technology can be advanced as a major element in a national energy plan or a commercial industry, more information is needed about its costs and environmental effects--information that can only be gained by building and operating a commercial-scale plant. Without Government support, industry is unlikely to build these plants because the gas produced would be too costly to compete with natural gas in the near future.

Satisfying the informational needs of high-Btu gasification, however, will not only help resolve the viability of the specific technology but also help alleviate the general uncertainties related to natural gas supplies. For example, the extent of conventional and unconventional gas supplies is uncertain. Further, an oil embargo more severe than that imposed in the seventies looms as a possibility that could force the Nation to rely heavily on gas supplies. Finally, the natural gas industry, particularly in recent years, has been in a state of flux, reacting to legislative and regulatory changes. Potential catalysts for future fluctuations include

--relaxing limits on the industrial use of natural gas,

--opening more Federal lands to gas exploration, and

--hastening decontrol of natural gas prices.

FIRST COMMERCIAL PLANTS WILL NEED COORDINATED SUPPORT

The national benefits of commercial demonstration suggest Government support. Since high-Btu gas plants will not sustain themselves, at least during the first several years (see pp. 17 to 21), private funds to construct them are not readily available. Investors will not use their own capital to go it alone, and lenders will not lend without guarantees. Ratepayers have

resisted paying more than the gas is worth to them. Therefore, if high-Btu plants are to be built in the near future, SFC support will evidently be necessary.

Private sources will not fully support

The most likely source of funds would seem to be those who stand to profit from the plant's operations--gas distributors and coal owners. Some of these companies have offered to sponsor projects; however, they do not want all the risks and have difficulty raising the capital. They have sought support from lenders, but the lenders require a guarantee of repayment plus interest.

Gas distributors simply have limited capital to fund commercial gas plants. In some cases, the estimated capital cost approximates the sponsors' total assets. The Tri-State project, for example, is sponsored by subsidiaries of two large energy corporations whose combined assets total about $4.5 billion (according to 1979 figures). The estimated capital cost of $3.5 billion in 1980 dollars is over 77 percent of these assets. As for Great Plains, the primary sponsoring firm set out to build a full-sized plant by itself but realized it couldn't. To control capital costs, it first cut the plant size in half, then added one partner, and finally took on two more partners. Even with the downsized plant and the additional partners, the sponsors expect to fund only one-fourth of the cost and borrow the remainder under a Government guarantee.

While regulation ensures pipeline companies a comparatively secure return that would be adequate to repay lenders and investors under traditional activities, the same regulation keeps rates of return too low to allow an undertaking with significant risk. According to the primary sponsor of Great Plains, a regulated gas company has no prospect for a high rate of return that might justify the heavy risk of a coal gasification plant. They believe the risk is not any large probability of technical failure but rather the changing environmental, economic, and political climates and the increases and uncertainties in project cost.

Coal-owning firms outside the regulated gas industry have different perspectives. An official of a large oil company stated that gasification efforts have to compete with diverse projects for the corporation's capital. Before the firm would fund a commercial gasification demonstration, the estimated return on capital from the gas plant would have to compare favorably with the estimated return from alternative investments such as oil exploration. All three frontrunner commercial projects covered in our review are sponsored by firms that are principally gas oriented.

Because these firms can fund only a portion of a gasification plant's huge cost, they have turned to lenders to finance the rest. The three commercial projects reviewed all plan to draw fully 75 percent of their capital from lenders. Yet, since these plants are the first of a kind in this country, lenders are

simply unwilling to participate without a guarantee that they will recover their funds with interest. Collateral is a common type of loan guarantee, but virtually meaningless in this context. Unless the plants operate profitably, they will be of little value.

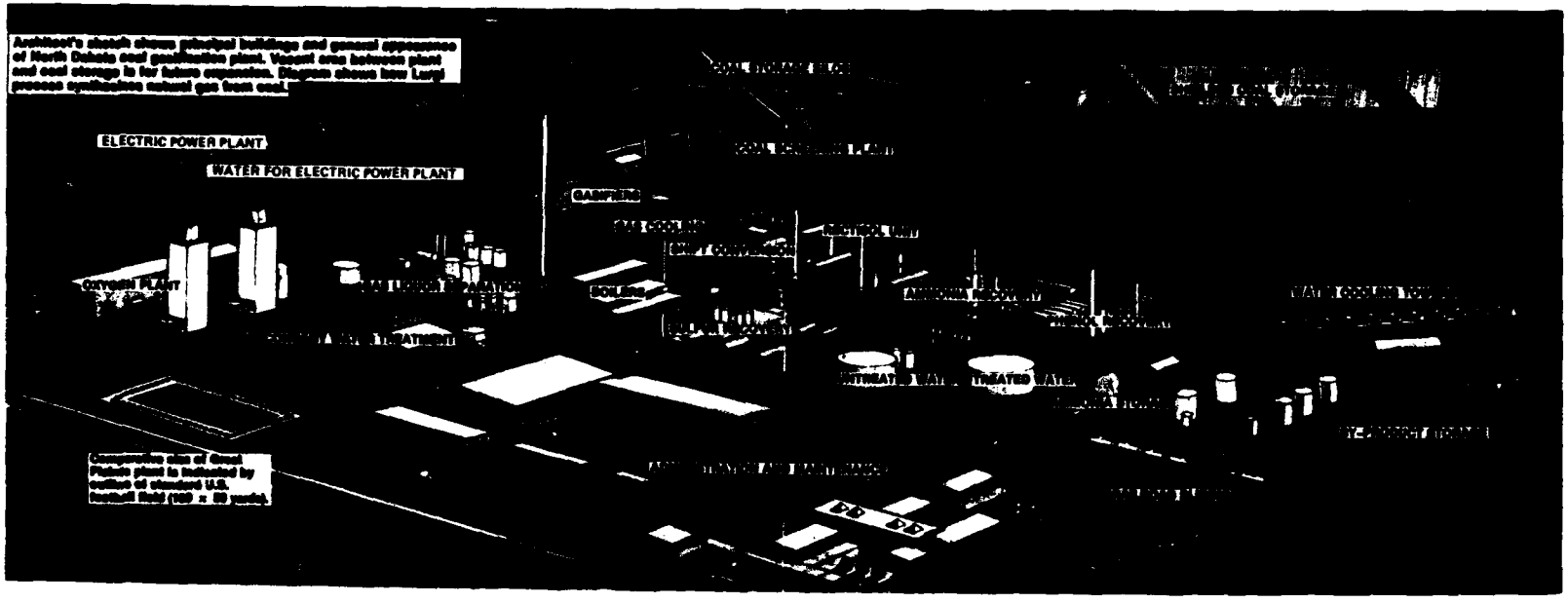
To add to the lenders' concern, sponsors have structured their projects as legal entities separate from their other activities. Thus if sponsors default, lenders have no right to their other assets, only to the project itself. Therefore, the only way lenders will support the first gas plants is with a Government guarantee of repayment. Such guarantees became available under synthetic fuel legislation of 1978-80.

Ratepayers will not fully support

Loan guarantees can cover only 75 percent of a plant's costs, so the sponsors must supply the rest. The sale of plant gas must somehow give them an adequate return on this investment plus sufficient revenue to repay the loan with interest. Since the gas will cost more than natural gas for the first several years, subsidy by someone is inevitable. Gas ratepayers, who currently do not need a supplemental source of gas, have resisted paying a premium price for this gas.

Customers apparently will subsidize the Great Plains project (see project illustration on p. 47), but only as a unique case. Originally, the sponsors applied for FERC approval to charge ratepayers for the full cost of service, overruns, a return on the sponsors' investment, interest on loans, and the risk of failure. Ratepayer representatives objected strenuously, however, and the eventual result was a prefixed price agreement. Under this agreement, ratepayers bear no risk of failure or cost overruns, but they do risk the possibility that the escalated price of the plant gas will exceed the price of alternatives. In agreeing to this arrangement, both FERC and the ratepayer representatives made it clear they considered it a special case that was unlikely to recur. Thus any further coal gas plants cannot rely on the ratepayers to buy the gas at premium prices but must depend on price supports available from SFC.

Project sponsors have yet to address the specifics of price support. Great Plains officials stated they do not need price supports with the tariff approved by FERC. WyCoalGas was interested in a similar pricing agreement, but its pipeline system would involve three of the contesters of the original Great Plains tariff. It has requested an SFC price guarantee but has not defined the amount needed. Tri-State officials stated their project's economic picture is not yet clear enough to tell what individual products would cost, but they assume some price supports may well be needed.



GREAT PLAINS COAL GASIFICATION PLANT
65 MILES NORTHWEST OF BISMARCK, NORTH DAKOTA

State support will be limited

States where the large projects are to be located can be counted on only for limited, peripheral support. States are making project development easier by coordinating required permits and by assisting in site selection. For example, Kentucky helped the Tri-State project locate a site and obtained options on the land for the project. Kentucky also technically and financially assisted the Tri-State project in obtaining coal samples and sending them to South Africa for tests. However, our discussions with State officials disclosed that financial assistance to projects for loan guarantees, price supports, and the like appear to be beyond the capability of States. According to State officials, they will have enough to do dealing with adverse socioeconomic impacts. While States may eventually benefit economically by the use of their resources (such as coal and labor), they will not necessarily receive the direct benefit of the products. In the instance of the Great Plains project to be located in North Dakota, the State will not receive any of the high-Btu gas produced. Rather, Great Plains gas will be shipped to numerous Midwestern and Eastern States. This market dispersion suggests that project support through intrastate tariffs is unlikely for large plants.

Plant support should be balanced and coordinated

Thus, if any high-Btu coal gasification plants beyond Great Plains are to move forward, SFC support will apparently be viewed as an important part of a balanced and coordinated effort with project sponsors and gas users. A balanced agreement is needed to spread financial support for high-Btu gasification among the investors, the lenders, the ratepayers, and the Government. If one group is asked to pay more than it considers reasonable, the projects are probably doomed from the start. To achieve the agreement will require coordination between SFC and FERC.

Investors must bear a real portion of the risk. If ratepayers or taxpayers perceive project sponsors are getting a free ride, they will surely object. One of the main sticking points in the first Great Plains proposal was that sponsor risk would be passed off to ratepayers. Further, sponsors will probably be more diligent when their own money is at stake. Lenders, of all the involved groups, have the least to gain from high-Btu gasification. They are not in business to promote any particular resource, technology, or product. What they lend money for is really of no concern to them as long as they can expect to be repaid and earn a competitive interest rate. Until commercial high-Btu gasification is economically, technically, and environmentally proven in this country, lenders are unlikely to do more than fund Government-guaranteed debts. SFC can ensure that sponsors and lenders bear an appropriate burden.

However, FERC is the agency suited to determine how much the ratepayers should pay for the gas. FERC may decide, for example, that the high-Btu gas is worth as much as the most costly equivalent volume of natural gas purchased by the pipelines. Once FERC has set the value, the price must be "rolled in," averaged into the price of all gas purchased by the pipelines' customers. If it is charged to particular customers, they are likely to find it too expensive and buy an alternative fuel.

The table below shows examples of how rolled-in pricing of coal gas might affect consumers' gas bills. These calculations assume that consumption will increase slightly to absorb the coal gas that becomes available.

Coal gas cost as a percent of average natural gas cost	Percent increase in average price of all gas if coal gas comprises an additional	
	1 percent of supply	2 percent of supply
250	2.5	5
500	5.0	10
1,000	10.0	20

As an additional example, if, when natural gas averaged $1.60 per million Btu, a plant was contributing 1 percent to the supply at $6.75, the receiving pipelines would pay about 4 percent more for their total supply.

As long as the supply of coal gas is kept low initially, the consumers' burden will not be overwhelming. As time goes by, the cost of natural gas is expected to catch up with the cost of coal gas, lifting the burden. (See pp. 19 to 20.)

In the meantime, the Government could provide loan and price guarantees. Combining types of support will involve certain complexities. Loan guarantees would take care of the lenders' need for security and would become an actual cash outlay in the event of plant failure or abandonment. With only loan guarantees, the Government's involvement in project affairs would be relatively low, since its function would be similar to an insurance company. However, the price guarantee, to make up the difference between ratepayer price and the revenue the project needs, would more likely be an actual cash outlay and require much more Government scrutiny. SFC would have to review prices and costs for reasonableness.

Price guarantees could amount to a sizeable subsidy. One dollar of support per million Btu would cost SFC $46 million a year at a plant the size of Great Plains. To prevent a "bottomless purse" approach and provide project sponsors an economic incentive for prudent management, SFC should limit price guarantees to a negotiated maximum amount and timespan.

Price guarantee is more complicated for a plant where gas is only one of several primary products than for a plant producing principally gas. In a gas plant, revenues from byproducts such as sulfur are deducted from costs which the gas must bear. In a mixed plant like Tri-State, byproducts are treated similarly, but the various primary products must each bear a portion of plant costs. If the Government is to guarantee the price of some of the products but not all, it must ensure that the allocation does not unduly weight the price-guaranteed products.

Finally, although the price support would be in addition to the loan guarantee, SFC would at no time be liable for the entire loan guarantee plus the maximum price support. Price support payment, if needed, would begin as the plant started operations; at the same time, the project would begin paying off the loan. Thus the Government's liability for the loan would be decreasing as support payments mounted.

Aside from these complexities, there is the problem of getting the involved parties together. When project sponsors determine what price they must receive for plant gas, they may be faced with the dilemma of whom to firm up gas prices with first--SFC or FERC? If these agencies act independently, they will make it difficult for the sponsors to arrange a viable pricing package. Sponsors will have to approach one agency without knowing how much support to expect from the other. FERC must determine how much the plant's gas is worth to customers, considering alternative sources of fuel. SFC must decide how much the demonstration is worth to the Nation, considering alternative projects. FERC and SFC officials have not coordinated with each other, and both stated a sponsor has to apply to them directly.

A similar problem troubled DOE's aborted demonstration program. DOE wanted project sponsors to obtain regulatory approval for passing on research and development costs, investing in construction, and selling plant gas, before it would fund construction. Sponsors, however, thought it best to wait for DOE's commitment before they approached regulators. This conflict was never resolved.

SECOND GENERATION COULD CONTRIBUTE TO SFC GOALS

Two of the three commercial projects we reviewed, as well as nearly all the high-Btu gasification projects submitted for SFC funding, intend to use first-generation processes and western coal. The second generation, however, offers the capability of gasifying eastern coal and thus could contribute to a geographically balanced synthetic fuel program. DOE's demonstration of second-generation technology, which had yet to get off the ground when the Reagan administration ended it in 1981, would not have led to commercial production until at least 1993. Yet the processes being considered could be accelerated to contribute both information and production to SFC's goals. While the Reagan

administration suggested that the demonstration projects seek SFC support, they have not done so and financing obstacles may stand in their way.

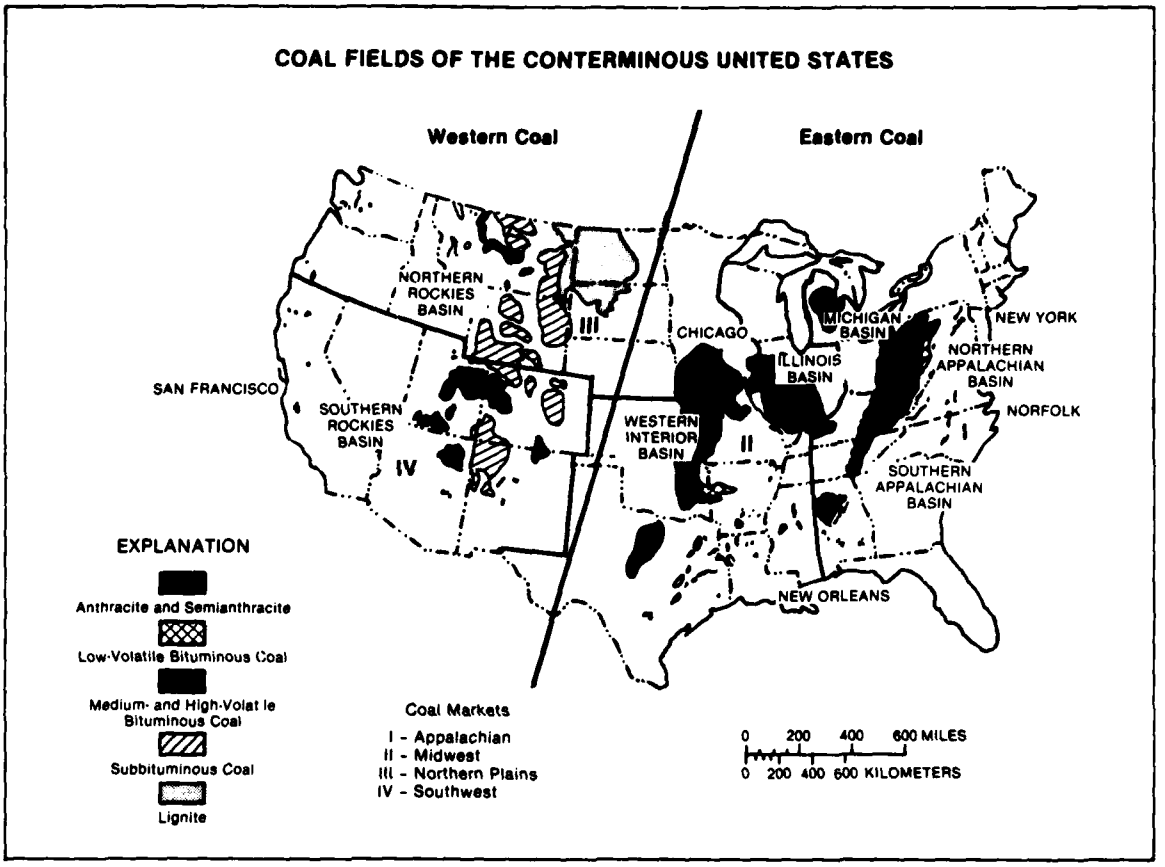
Eastern coal important for balanced synthetic fuel program

Second-generation processes are important chiefly because they can use eastern coal efficiently. Aside from the inherent advantages of eastern sites for coal gasification plants (see p. 50), they can help provide geographic balance to the synthetic fuel program and an eventual industry stemming from it.

Not only first-generation high-Btu gas plants, but also shale oil plants will be located in the Western United States. Shale plants, in fact, will be concentrated in a small area at the corners of Colorado, Utah, and Wyoming. Synthetic fuel plants will have considerable environmental and socioeconomic impact on their locations. Potential environmental consequences include air and water pollution and hazardous waste disposal problems. Socioeconomic effects have been characterized by DOE as:

> "* * * stresses on worker availability; Government provided services such as schools and police protection; transportation; housing; local tax structures; and inflation. All of these impacts can be expected to affect the local standard of living in a dramatic and transient matter as the large construction work forces come and go and are replaced by a much smaller and permanent group of personnel who will operate the plant. The magnitude of these impacts will be a function of the current population characteristics and should decrease in already industrialized areas of the East where most of the personnel and supporting structure is already in place. * * *"

The more concentrated plants are, the more severe the impact will be on a particular area. Most projects are sited near the resources they use; otherwise transportation costs become prohibitive. Hence second-generation gasification technology offers one way of mitigating the impact of synthetic fuel plants on the West. The map shows the location of eastern and western coal resources.



Selected American coals have been tested under RD&D gasification programs. Gasification of lignite and subbituminous coal--like Western U.S. coals--was proven by the Lurgi process in commercial facilities. Bituminous coals can be highly caking and are generally considered less suitable for the Lurgi process. Since much of the vast deposits of Eastern U.S. coals are in the latter category, eastern coals became a primary target of the RD&D programs. Beyond the RD&D programs, planned commercial projects also conduct coal tests prior to final design of their projects. Two of the three commercial projects which we reviewed were planning to use the Lurgi process with a western coal. The other project, the TriState project, planned to test the use of a selected blend of moderately caking eastern coal from the Illinois Basin with a modified Lurgi gasifier.

Protracted program put deployment far off

Delays and controversy marked the second-generation demonstration program from its inception in 1975. Though the program was expected to take 8 years, by 1981 it was still in the first and shortest of three phases. If all had continued as planned during the next two phases, the program would still not have led to a commercial plant before 1993.

The Energy Research and Development Administration began the demonstration program to accelerate industry's adoption of second-generation technology by resolving the technical and economic uncertainties. In 1976 it selected two of five proposals and negotiated contracts to design a demonstration plant (phase 1). After the design phase, which was supposed to take 20 months, the agency would choose one of the two proposals to advance to construction (phase 2). The plant would begin 42 months of operation in 1980 (phase 3). But delays plagued the program, beginning with the negotiation of the design contracts, and by June 1981 the two contractors were just completing the design phase.

Of the five proposals submitted in 1976, ERDA ranked the top three technically in the following order:

--A proposal by Conoco to use a "slagging Lurgi" gasifier.

--A proposal by Texas Gas Transmission Corporation and the State of Kentucky to use the Hygas process.

--A proposal by the Illinois Coal Gasification Group (ICGG) to use the Cogas process.

Although ERDA intended to choose only one proposal for the design phase, it wound up selecting two--Conoco's and ICGG's. The reasons given were the high quality of the proposals and ERDA's belief that a synthetic fuel capability was essential to the Nation's energy future. The Congress kept the prospects for construction of two projects alive by authorizing some funds for both. It also kindled hope for a third demonstration project by later funding a preliminary design using the Hygas process. What began as a $20 million program for the design of one project ended up as a $106 million program with three designs. The table on page 55 summarizes the salient features of the three demonstration proposals, and appendix II provides overall information on each project.

The Conoco and ICGG projects were in direct competition, and DOE was to select a "winner" in mid-1981. In addition, because

of its technical and ecomonical merits the Hygas process was expected to be in the running if more than one plant were to be built.

ERDA did not select the Hygas project for the original design phase because the proposal did not meet its cost-sharing and management concepts. However, both Conoco and ICGG project officials later indicated they too would have problems meeting the agreed-upon cost sharing. (See p. 57.) Indeed, cost sharing and the competition between projects became controversial issues throughout the program. Other controversies included the scale of the demonstration plants, the control of technical information related to the processes, and the timing of applications for regulatory approval. These problems, as well as DOE's inability to provide funding continuity and stay within the time period for selecting a winner, were the primary causes for delays.

Approaching the demonstration program from a new perspective, in early 1981 the new administration requested that it be terminated. The Supplemental Appropriations and Rescission Act of 1981, approved June 5, rescinded $49 million previously authorized for the program in fiscal year 1981. DOE estimates it will take $3 million to terminate the projects. The administration's primary reason for requesting termination was its perception that the projects were going to demonstrate near-term technology with little technical risk; that task could be better performed by industry with support from SFC.

Characteristics of Proposed Demonstration Plants

	Conoco	ICGG	Hygas
Daily output and input	19 million cu. ft. gas from 1,250 tons Ohio #9 coal	23 million cu. ft. gas and 1,400 barrels fuel oil from 2,200 tons Illinois Basin coal	83 million cu. ft. gas and 752 barrels oil from 7,100 tons Illinois Basin coal
Plant cost	$317 million	$474 million	$600 million
Developer	British Gas Corp. and Lurgi Corp.	Cogas Development Co.	Institute of Gas Technology
Gasifier	Slagging Lurgi	Cogas	Hygas
Gasifier scaleup			
Pilot to demo	2.8 times	30 times	80 times
Demo to commercial	1.5 times	4 times	-
Pilot to commercial	4 times	120 times	80 times
Uncertainties			
Process	Operability on design coal	Operability when pyrolysis is combined with gasifier	Operational efficiency questioned
Environmental	Solid waste disposal	Solid waste disposal; safety of oil	Solid waste disposal

Had the demonstration program continued as planned and without further delays, the second-generation processes would have been unlikely to contribute to either the 1987 or 1992 synthetic fuel production goals. Under DOE's schedule, a demonstration would begin operation in late 1984 and finish in mid-1988. Allowing 5 years to design and construct a commercial plant, substantial production would not have occurred until at least 1993. At any rate, the projects now will merely complete the design phase and then shut down.

Potential for accelerated development

In ending DOE's demonstration program, the Reagan administration suggested that sponsors seek SFC support. Indeed, second-generation processes do have the potential to contribute to SFC's goals if their development can be accelerated. Many believe the technical risks to be manageable.

An accelerated approach would involve building one or more demonstration plants as commercial-scale modules. Assuming the demonstration is successful, and the economics support expansion, these plants could be built up to commercial size simply by adding modules. In contrast, the ICGG and Conoco demonstration plants as supported by DOE would have been built at about one-fourth to one-third the scale of a commercial module. Such plants would not resolve all the technical and economic risks of building full-scale plants and would probably be junked once operations concluded.

The commercial-scale module alternative was suggested to ERDA by the Exxon Corporation. Exxon cited several advantages; for example, a successful full-scale plant

--would be more convincing to industry and the financial community than a plant requiring further scaleup,

--would confirm solutions to socioeconomic and environmental problems, and

--would chart a path through the regulatory maze.

In short, such an approach would increase the chances for rapid commercialization.

Considering these intangible advantages, ERDA commissioned an independent comparison of the economic consequences of this alternative with its pilot-to-demonstration-to-commercial-plant approach. The study, published in 1977, considered coal conversion in general, not concentrating on any technology or process. It concluded that the two approaches would bring similar rates of return for investors. Although the commercial-scale module

approach would cause heavier losses in the event of failure, it would also result in earlier returns if it succeeded.

The large-module concept claimed support among the demonstration plant designers. The Hygas project, for example, was designed to be commercial scale. The sponsors envisioned buying out the Government's interest in the plant and expanding it to commercial size. ERDA evidently endorsed this design approach when it rated the proposal technically sound. Similarly, Conoco at first planned to build a commercial module, but reduced its design scale to cut costs and compete better for construction funds. Officials for both these projects stated that the technical risks of a commercial-scale plant would be manageable. Only ICGG, among the sponsors, appeared uninterested in building such a plant, but not for reasons of technical risk. Both ICGG and DOE officials said the risks of scaling up the Cogas process were acceptable.

One proposal submitted to SFC, the Ohio Valley Synfuels project, did include the process chosen by Conoco in a full-sized plant. It was the only high-Btu gasification proposal for eastern coal. An official of the primary sponsor stated that originally the project would have relied heavily on results from DOE's demonstration program. Now that this preferred developmental work will not go forward, the sponsor will rely on added developmental work by British Gas, the process developer. The project is not, however, irrevocably tied to the process; a final decision awaits further analyses.

Given that many believe the risks associated with second-generation technology are manageable, the commercial-scale module approach appears consistent with SFC's objective of speeding synthetic fuel production. The proposed Hygas module, for example, would produce the equivalent of about 15,000 barrels of oil a day, while an expanded three-module commercial plant would produce the equivalent of 50,000 barrels a day. (Because it makes disproportionately more byproduct oil, the full-size plant produces more than three times the output of one module.) Three second-generation plants, built on a modular approach, could contribute roughly 10 percent to SFC's first production goal and 8 percent to its second.

Projects of this type would compare favorably in production with the Ohio Valley Synfuels project, which proposes construction in three phases to produce high-Btu gas and methanol. By 1987 the first phase would be operational; it would use the Texaco gasification process, favored in several coal liquefaction projects, to produce 25 million cubic feet of gas and enough methanol to total the equivalent of 8,600 barrels of oil per day. By 1992, the project would have added a slagging Lurgi module to raise high-Btu gas production to 175 million cubic feet and total production to 34,500 barrels of oil equivalent. Compared with a project built as outlined above, this project would contribute

less production but would also demonstrate two processes and the production and marketing of methanol.

Obstacles to accelerated development

Pursuing the demonstration plants as commercial-scale modules with SFC support would entail several obstacles. The chief difficulty would be to get the sponsors and SFC together on the plants' size and funding. Legislative restrictions may preclude a suitable arrangement. Further, DOE can contribute to a better understanding of the merits of the technology and the accomplishments under DOE's management.

The Energy Security Act of 1980 authorized SFC to undertake joint ventures for synthetic fuel project modules. SFC can pay no more than 60 percent of the cost, and industrial sponsors must pay the remainder. The module must be sufficient in scale to prove the feasibility of the technology and to be expanded to a commercial plant at the same site. The requirement for a project module poses no problem from our point of view, since it is in line with SFC's goals and the technology's readiness. However, it might create difficulties for project sponsors, who must triple or quadruple the scale of their proposed plants and then provide 40 percent of the cost.

Rigid cost-sharing requirements have already caused problems in the demonstration program. The proposal for a Hygas plant, a commercial-scale module that received a high technical rating, was dropped from consideration because the sponsors failed to satisfy ERDA's 50-50 cost-sharing requirement. They offered to pay much of their half of costs out of plant gas sales, but ERDA rejected this offer, since it would have to bear more than half the risk of plant failure. Later, however, the sponsors who did receive design contracts asked to change the cost-sharing provisions. Conoco wanted credit for research expenses it had made, in some cases many years earlier. ICGG flatly stated it could not proceed to construction under the 50-50 concept. Both wished to use gas revenues as part of their contribution--just like the rejected Hygas proposal. Both blamed DOE for escalating costs by delaying progress and noted the improved supply of natural gas since the program began. Thus the cost-sharing requirement jeopardized the demonstration program even before the Reagan administration's intervention. 1/

Given that the prospective sponsors could not see their way to funding 50 percent of a third- or quarter-scale demonstration plant, they are unlikely to offer 40 percent of the cost for a

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1/Our 1978 review of the fossil energy RD&D program recommended that the Secretary of Energy adopt a more flexible policy for cost sharing.

full-scale module. An American Gas Association official, testifying at a congressional hearing, suggested changes to accommodate demonstration plants applying for SFC funding. As it is, joint ventures require a 40-percent investment by sponsors, and loan guarantees require only 25 percent. He felt contributions should be treated equally under the two forms of assistance. Also, he asserted that project sponsors of demonstration plants should be able to contribute a portion of their equity through revenues from the first year's sales of the fuel produced.

Besides its cost-sharing requirements, the Energy Security Act limits the chances for demonstration plants in other ways. It emphasizes projects with high output at low cost and minimum SFC financial commitment. It specifically assigns joint ventures a low priority.

Need for a DOE assessment

Although the administration's position is that the demonstration projects can move to SFC, there are clearly problems in doing so, and DOE seems disinclined to assist the process. DOE has dealt with the projects over a number of years, but its conclusions about them are uncertain. It has evaluated the projects from time to time and raised questions that have never been resolved. We believe that DOE, as the agency responsible for energy policy, should evaluate the merits of the technology and the program's accomplishments.

The last DOE evaluation of the projects, in April 1980, raised serious questions regarding the availability of information for commercializing the processes and for weighing technical risks. According to the DOE patent counsel, the ultimate availability of technical knowledge from the Conoco project is in doubt because of restrictive provisions that subcontractor license holders insisted on. The counsel further pointed out that the ICGG contract gives DOE no rights on licensing third parties for inventions made as part of the project. ICGG merely stated that such licenses would be issued if the need arose. Another issue during the evaluation was whether the gasifier intended for the Conoco project could successfully process the chosen Ohio No. 9 coal. Data available to DOE evaluators indicated that it could not. The developer later claimed it could, but on proprietary grounds did not provide test data as proof to either DOE or Conoco. These problems were never resolved. Also left unfinished is a study of the costs and markets for the projects. Some work was done during April 1980, but the reports noted that final cost and market studies would have to await complete designs.

Although some documents suggest that DOE will assemble an information package on the demonstration for SFC, officials stated in July 1981 that they do not anticipate preparing a formal evaluation or making recommendations to SFC. They consider the demonstration program a "dead issue." Yet SFC officials said they were trying to understand the high-Btu gas demonstration

program since they had an implied charge to look into the projects' potential, but had not received any proposals. We believe the best way for SFC to get a clear understanding of the demonstration projects is for DOE to make a complete, final evaluation.

OPPORTUNITIES FOR STRETCHING LIMITED FUNDS

Although commercial demonstrations of high-Btu gasification have benefits, the funds devoted to them will necessarily be limited. In the first phase SFC will have less than $18 billion for synthetic fuel plants of all types, and all of them will be expensive. In funding any high-Btu gasification, SFC should bear in mind the similarities between this technology and indirect liquefaction and opportunities for limiting the size of the plants. In this way SFC can promote greater diversity while limiting the commitment to any one process.

Demonstration does not require full commercial size

For purposes of demonstration, a plant need only have commercial-scale modules; it need not be a full-sized commercial plant. Authorities in coal gasification have traditionally considered a plant producing 250 million cubic feet per day to be full-sized, but this size is meant to yield optimal economics for factors, such as coal and ash handling, rather than any technological efficiency. In fact, the full-sized plants are merely modules replicated to reach a given volume. Thus, with relative ease, plants can be halved or quartered.

Among the commercial projects reviewed, Great Plains is already at half size; that is, it has a production capacity of 125 million cubic feet per day. Originally full size, it was reduced to cut capital costs. Similarly, WyCoalGas is designed as a full-sized plant of 300 million cubic feet per day, but plans are to build only half of it at first. Building in stages was conceived to spread out capital costs and socioeconomic effects. Both Great Plains and WyCoalGas have requested loan guarantees from DOE and SFC covering only half plants.

Tri-State, on the other hand, is to be a full-sized plant producing about 150 million cubic feet of gas per day, as well as liquid fuels and chemical feedstocks. (The total would be equivalent in heating value to a gas plant producing over 300 million cubic feet per day.) The sponsors prefer the full-sized plant since it would allow complete processing of the liquids to marketable products. Halving the plant would limit the products to high-Btu gas and synthetic crude oil, because a refinery would not be economically justified with less than a full-sized plant. Yet the full-sized plant would cost an estimated $7 billion, while SFC assistance to any single project can be no more than $3 billion in the first phase.

Officials from all three projects stated smaller plants would significantly reduce capital costs. Tri-State officials estimated that halving their plant's size would reduce capital costs by 40 to 45 percent. Great Plains figures show that halving the size reduced estimated capital costs by about 40 percent. WyCoalGas estimates were more preliminary, but officials acknowledged that building the plant in stages would significantly reduce the initial need for capital.

While the plants can be a quarter of their size for even more reductions in capital, too much of a reduction can increase gas costs severely. During hearings on Great Plains, one of the protestors suggested reducing the plant from halfsize to one commercial-scale module (a quarter-sized plant), saving an estimated 35 to 40 percent. However, as plant size continues to decrease from the theoretically optimal, gas costs per unit increase more significantly. The industry consensus, according to the Gas Association, is that gas cost increases only 10 percent when a plant is halved from 250 to 125 million cubic feet per day, but reduction below 125 million cubic feet per day would have serious repercussions for marketing the gas.

Whether reduced plants would be eligible for SFC assistance is unclear. The legislation setting up SFC requires that loan and price guarantees go to projects "for the purpose of commercial production of synthetic fuel." However, nowhere is commercial production defined in the law, and SFC officials have not determined yet what plant size they will consider commercial.

Beyond that question are conflicts between various SFC objectives. Among other things, SFC is charged with

--achieving certain production levels with a limited amount of assistance,

--favoring projects that minimize its financial commitment and the unit cost of production, and

--seeking diversity of technologies, processes, and resources.

The first two objectives would encourage SFC to support efficient large plants using the most economical technology, which appears to be shale oil extraction. According to the American Institute of Chemical Engineers, shale oil is expected to cost the least per Btu of the big three synthetic fuels, with high-Btu coal gas next, and coal liquids most expensive. Moreover, some liquid fuels like gasoline command a higher price per Btu than natural gas, which is regulated. Finally, liquid projects tend to be sponsored by oil companies, who are richer in capital than the pipeline companies that tend to sponsor gas plants. Thus they will probably need less assistance.

So far, DOE, under its interim program, has conditionally awarded financial assistance to two shale oil projects totaling $1.5 billion. The larger commitment was for a $1.1 billion loan guarantee to produce 48,300 barrels of oil output daily, or a $23,000 commitment per barrel of daily capacity. In comparison, Great Plains required a loan guarantee of $2 billion for the equivalent of 22,000 barrels of output, or about $91,000 per barrel. This wide disparity occurs partly because one of the shale plant's sponsors, an oil company, is picking up 60 percent of the tab and requesting no SFC assistance. Another reason is that the shale plant is to be built at closer to optimum size, while Great Plains is a half-sized plant. At any rate, high-Btu gas, particularly plants of reduced size, will seem a poor investment for SFC from a strictly economic viewpoint. On the other hand, it would help to meet SFC's objective of technological diversity. Furthermore, the close relationship between coal gasification and indirect liquifaction suggests another way of pursuing diversity with a limited commitment.

Similar plants have little demonstration value

Many coal conversion proposals, both gasification and indirect liquefaction, use the same basic Lurgi process as the first step in their plants. SFC can make use of this fact to select a portfolio of a few projects that would utilize different subprocesses or various coals to obtain an array of products, leaving some funds to demonstrate other types of processes.

Industry sponsors are clearly turning to the Lurgi process and western coals for near-term high-Btu production. Of the proposed feasibility studies for high-Btu coal gasification DOE evaluated, about half intended to investigate the Lurgi process and western sites. A few sponsors did propose other processes such as Cogas, slagging Lurgi, or Texaco; however, only the last two processes later appeared in project proposals before SFC. This left five of seven serious high-Btu coal gasification proposals to SFC electing the Lurgi process and western coals.

The Lurgi pressure gasification process is a basic process which initially produces a medium-Btu gas that can pass through four alternative subprocess routes to produce different synthetic fuels. These routes have all been represented in projects submitted to SFC. They produce (1) a high-Btu substitute for natural gas, (2) methanol, (3) a mix of liquid products and a natural gas substitute, and (4) gasoline. Lurgi gasifiers were also represented among medium-Btu gasification projects.

Informational needs can be met with only a few plants, since similiar plants using the same basic technology on the same or similar coals will add only marginal information. All three of the commercial high-Btu coal gasification projects we reviewed planned to use the Lurgi process as the basic technology. On the

other hand, all are distinctive in some manner. The following chart shows some of these major differences:

Feature	Great Plains	WyCoalGas	Tri-State
Coal:			
Type	Lignite (western)	Subbituminous (western)	Bituminous (eastern)
Caking	None	None	Moderate
Sulfur content	Low	Low	High
Mine type	Strip	Strip	Underground
Basic technology	Lurgi	Lurgi & Texaco	Lurgi & Fischer-Tropsch
Products other than high-Btu gas	Byproducts only	Byproducts only	Liquid fuels and chemical feedstocks
Disposition of tars, phenols, etc.	Burned to generate steam	Recycled and gasified	Refined to other products
Location	North Dakota	Wyoming	Kentucky

The chart is not to suggest that we endorse all or any of these projects or the Lurgi process above others, but rather to show the kinds of differences which might be considered in weighing a project's informational merits. Other factors also have to be considered, such as the sponsor's competence, experience, and willingness to bear a proper share of risks and costs.

The chart also highlights the similarities between coal gasification and coal liquefaction projects. For example, although the Tri-State project could be considered a coal gasification project because high-Btu coal gas was its main single product and almost half its total output, DOE and the project sponsor considered the project to be coal liquefaction because over half its total output comprised liquids of various types.

The aspects shared by coal gasification and liquefaction projects were further highlighted when the Great Plains project sponsor sought DOE feasibility study funding for a project to produce gasoline adjacent to their gasification plant. The sponsors pointed out that detailed engineering was well underway for the gasification plant, about 70 percent of which--the "front-end"--would be identical to the liquefaction plant. While the project offered apparent potential for early construction, cost saving, and partly completed environmental work, it was rejected because of the duplication between its geographical area

and coal type and those of other coal liquid projects. Clearly, rejection could have also been justified by the similarities between the processes.

While the Lurgi process dominates the high-Btu coal gasification proposals to SFC, other processes using eastern coal are more prevalent among medium-Btu gasification and indirect liquefaction proposals. Some of these projects also have some demonstration value for a future high-Btu coal gasification industry. Thus SFC should carefully weigh the information value of each project in terms of product, process, and coal use. In this way it can maximize the informational benefits of diversity while stretching limited funds.

CONCLUSIONS

There is a continuing interest in high-Btu coal gasification as an environmentally clean way of using the Nation's vast coal reserves, as a substitute for imported oil, as a backstop in case energy shortages require depletion of its natural gas reserves, and as a long-term supplement to natural gas. To make these uses practical, commercial-scale plants could provide valuable information about gas costs and environmental impacts.

Even a few plants are unlikely to be built, however, without Government support. Private firms are unwilling to risk the large amounts of capital required, until the economics of the technology have been proven. Gas customers have lent some support to one plant, but only as a unique case. Even then, a Government loan guarantee was necessary. Any further plants are likely to need price guarantees as well for the sale of their expensive gas.

Proposals to SFC have favored processes already proven commercially abroad. Other processes have been tested only in pilot plants but offer the advantage of efficiently using eastern coal. These processes were advancing slowly under a DOE demonstration program but the Reagan Administration closed that avenue for their development.

Yet plants using these processes could contribute both information and production to the synthetic fuel program if they were built as commercial-scale modules and then expanded, if appropriate, with additional modules. Such an approach seems to imply a joint venture between SFC and commercial sponsors because the joint venture provisions of the Energy Security Act expressly provide for commercial scale modules with later expansion to full-sized plants. However, joint venture provisions have not attracted any proposals for high-Btu gasification and this limits SFC considerations of this avenue for the immediate and possibly extended future. DOE's role as an energy policy agency and its long experience with second-generation processes put it in a position to assess their merits and suggest ways of accelerating them. GAO believes that the Corporation needs this assistance

within the near future, or 90 days, so that it still has the time and funds to consider support for projects using eastern coal.

Though high-Btu gasification demonstrations could contribute substantially towards solving the Nation's energy quandary, they will have to compete for SFC assistance with other projects whose economics may be more attractive. Whether these demonstrations will proceed is up to SFC. If SFC decides to include them in a diverse program of synthetic fuels, they should consider opportunities to limit the size, thereby stretching limited funds. Such plants would cost more per unit of production, but would minimize the financial commitment to any single process and resource, thus allowing more diversity. Another way for SFC to foster diversity while conserving funds is to recognize that certain processes can be used to convert coal to various products and then consider the selection of dissimilar processes to broaden the demonstration base of both processes and products.

RECOMMENDATIONS

To assist SFC in developing its program, we recommend that the Secretary of Energy:

--Evaluate the importance of the high-Btu second-generation process as a method of using eastern coal, and the prospects for accelerating the processes as commercial scale modules. As part of this evaluation, DOE also needs to consider other coal gasification and indirect liquefaction options.

--Report, within 90 days of the date of this report, to the Synthetic Fuels Corporation's Board of Directors on the potential role of second-generation processes in the synthetic fuel program, the availability of information needed for commercialization, product costs and markets, and technical and environmental risks.

CHAPTER 5

AGENCIES' COMMENTS AND OUR EVALUATION

We provided draft copies of this report to the Department of Energy, the Synthetic Fuels Corporation, the Office of Management and Budget, and the Federal Energy Regulatory Commission for their review and comment. Except for OMB, agency comments were received in time to be considered in this report. The full text of the replies are included in appendices III to V.

SFC said the report provides a useful perspective on many issues regarding the proper role of Federal agencies, private industry, and the Synthetic Fuels Corporation in the development of improved national capabililties for producing synthetic substitutes for conventional oil and gas.

SFC stated, however, that the report's emphasis on high-Btu gas and a limited set of "second-generation" coal gasification technologies seems to unnecessarily narrow the range of focus in a manner counter to that of the market place. SFC indicates, as does our report, that various liquid products can be produced using indirect liquefaction which incorporates coal gasification processes. It also states that the prospects for these liquid products, such as methanol, gasoline, and middle distillates, must also be considered by the SFC. SFC stated that proposals incorporating new technologies would be considered along with others that may be submitted to them.

We have included additional language in the scope and other sections of the report to recognize that coal can be used in several ways for energy as a direct energy source by burning, or gasification or liquefaction.

In its reply FERC said that it had no comments to provide.

DOE acknowledged that the report makes several valid points but did not agree with the report in general. DOE agreed that energy research and development should be funded according to national priorities and that any research more appropriately funded by industry should be eliminated from current budgets as swiftly as feasible. However, without providing any details on planning improvements or budgetary eliminations, DOE asserted that their revised fiscal year 1982 budget reflected this philosophy. In their other comments, DOE disagreed with our characterization of their research, development, and demonstration program.

Specifically, DOE stated that a critique of large scale practical demonstration projects in terms of the characteristics of routine small scale research and development is inappropriate and misleading. DOE contrasted the differences in visibility,

objective specificity, and results conclusiveness that exist between the larger and smaller scale projects. DOE concludes that it is not sound logic for GAO to couple these research programs and equate their management methodologies.

We agree that there are basic differences in the nature of and the outcomes expected from large and small scale research projects. However, we believe our report adequately recognizes these project differences. Also, we believe that both large and small research and development projects need to be fully justified on a basis consistent with overall Government policy objectives, defined research and development criteria, and specific technology strategies.

REPORT ON SECOND-GENERATION PROCESSES

DOE's reply did not address our recommendations calling for a report on second-generation processes. SFC said the report would be useful to it as well as many other persons and organizations and believed the report need not be directed specifically to SFC. We believe the preparation and usefulness of the report would be better assured if it were directed to the SFC, as recommended since SFC is the focal point for commercialization of energy technologies in this country.

SFC also said that if a DOE study on coal gasification processes is prepared, it might be more useful if it provided data on all coal gasification technologies including those oriented toward synthesis gas production and those being developed by the private sector. We agree that in evaluating the importance of high-Btu technologies DOE should consider the market potential of other near-term gasification processes, including indirect liquefaction and low- and medium-Btu coal gasification options as alternate methods of using eastern coal. The report will be useful not only in establishing the range of near-term eastern coal options, but also in aiding the refocusing of DOE's program towards longer range coal and surface gasification research. In this regard, our recommendation that the Secretary of Energy evaluate the second generation high-Btu processes importance as a method of using eastern coal will require DOE to consider indirect liquefaction and low- and medium-Btu coal gasification options.

ENVIRONMENTAL RESEARCH ON LARGE-SCALE DEMONSTRATION OR COMMERCIAL PROJECTS

DOE said that its actions for major gasification projects contradict our conclusion that it has neglected needed environmental research for major gasification projects. DOE said that each project, while active, complied fully with environmental requirements. DOE said that the environmental, health and safety concerns with respect to the demonstration projects

still exist but are now the responsibility of the projects' sponsors. DOE believes the recent redirection of fossil energy programs toward longer range coal research has reduced the requirement for an accompanying DOE health and safety program. We recognize in the report (see pages 34 to 36) that DOE had identified significant environmental health and safety problems impeding development of high-Btu coal gasification technology. However, efforts to collect data met with limited success because the pilot plants did not lend themselves to accurate projection of commercial plant emissions. Although DOE intended to address these problems in connection with the first demonstration and commercial plants, these plans have been dropped. Confirmatory data and research is still needed on these first-of-a-kind large scale projects. Also, much of this research is beyond what project sponsors could be expected to agree to as part of their environmental compliance and operating requirements.

DOE refers to its formalized environmental planning activity, i.e., technology-specific environmental development plans, as evidence that the Department's process demonstration program has been interrelated with its environmental research activities. DOE prepared these plans to help fulfill the Department's responsibility to develop environmentally acceptable energy technologies. Although environmental development plans were prepared for the coal gasification program, they were linked in part to DOE's plans to fund the high-Btu demonstration projects (the second generation Conoco and ICGG projects) and did not contain any indepth discussion of the first generation Lurgi process which was to be used in the Great Plains and other projects we reviewed. Thus, the plans for the synfuel projects in Kentucky and Minnesota, which are mentioned in DOE's reply, do not address the environmental issues raised in this report.

CHANGES IN RESEARCH AND DEVELOPMENT PLANS AND BUDGETS

DOE agreed that an energy research and development program should be funded according to national priorities and that any research more appropriately funded by industry should be eliminated from current budgets as quickly as possible. DOE said that Federal involvement will be limited to those promising areas of energy technology where the private sector is unlikely or unable to invest. Contrary to DOE's reply which suggests that the surface gasification plans and budget have already been refocused, much of the decisionmaking remains. These actions include defining the focus and objectives of the instrumentation and materials research; determining the future role of the Bigas, Westinghouse, and Rockwell facilities; and evaluating and redirecting the Advanced Research and Technology Development funded efforts to eliminate unproductive projects and establish an appropriate balance in technologies.

The unsettled nature of the program was also evident from continuing actions on the revised fiscal year 1982 budget which DOE submitted to the Congress in September 1981. This budget requested $64 million for the surface gasification program including $53.4 million under the surface gasification activity and $10.2 million for coal gasification under the advanced Research and Technology Development (ARTD) activity. This budget included support for R&D which could be performed by industry. For example, after the budget was revised and submitted to Congress, the Congress cut $9 million requested for the third-generation Exxon process and affected an additional $1 million reduction from the ARTD activity. Also, in March 1982 DOE requested deferral of another $6.2 million in surface gasification funds, most of which was related to the termination and elimination of high-Btu process research mentioned in our report. This latter request was a part of the administration's continuing efforts to deemphasize support for near term process research and refocus the program to more generic and technology based research.

In its comments on our report, DOE rejected our recommendation that DOE define "long term," "high risk," and "high payoff." DOE said that the phrases were not intended to be precise delineators and the project selection demands a strong degree of flexibility. Also, DOE believes that the choice of which projects were long term, high risk, and high payoff would be best left to R&D program managers who have technical perspective to make the necessary judgments concerning the benefits of projects and are capable of determining the appropriateness of Federal funding by following the guidelines established by the Secretary, and the appropriate Assistant Secretary.

We recognize there has to be some flexibility in determining R&D project funding. We also recognize there can be no identical boundary line for all technologies given the differences in markets, competitive economics, and the prospects for significant R&D improvements. However, in order to provide some meaningful focus on R&D, there has to be some defined criteria; and if the criteria is to include "long term," "high risk," and "high payoff," these terms should be defined. For example, we suggest that long term could be defined in years to commercialization and remaining R&D assessed in light of that criteria. High-payoff criteria could include a range of production cost savings or greater efficiencies over commercially available technologies.

As DOE moves away from the near term development towards more generic and technology based research, the need for the above definition becomes more acute. Also, the Department's programs take on a scope more closely related to that of the

GRI program. How DOE's Government role is defined will undoubtedly impact on whether GRI and DOE should conduct joint or separate programs for high-Btu coal gasification.

COAL CONVERSION PROCESSES

Any plan which purports to increase the domestic energy supply must include use of the Nation's vast coal reserves. Fortunately, coal can be used in several ways for energy and more ways are being developed. Coal can be used as a direct energy source by burning, or it can be converted into a variety of other fuels or chemical feedstocks through gasification or liquefaction. The following is a very generalized description of the ways to use coal as well as descriptions of the differences in the processes to be used at the six high-Btu gasification projects contacted during this review. There are some long-term coal technologies such as in situ gasification and magnetohydrodynamics which are not discussed here since these are not expected to be of any commercial consequence before the 1990s.

Direct burning is, of course, the simplest and probably most efficient use of coal. Most direct burning in the world today is to create steam to generate electricity or for industrial processes. Coal is fed to boilers where it is burned either in pulverized form or on moving grates. A more advanced technique is fluidized-bed combustion, where the fine coal is suspended on air within the boiler. Coal can be mixed with oil to enable oil-burning units to partially convert to coal use and thereby conserve petroleum. Direct burning, however, has well-known environmental problems and is really suitable only for large-scale stationary uses.

Coal can be converted to other fuels with purportedly fewer environmental objections than direct burning and with more uses. Products such as high-Btu gas, gasoline, diesel fuel, jet fuel, and alcohol can be made from coal. The conversion processes are gasification and liquefaction, although there is a great deal of overlap between the two.

Liquefaction, that is to say converting coal to emphasize liquid products, consists of three basic processes--pyrolysis, indirect liquefaction, and direct liquefaction. Pyrolysis is the thermal decomposition of coal in the absence of oxygen. This breaks the coal into two fractions: one rich in carbon (char) and one with most of the hydrogen (oil). One of the drawbacks to date has been the low yield of liquids, about a barrel or less per ton of coal. However, the char can be gasified, as it is in the Cogas system and, according to DOE, the prime application of the process may be where gases, not liquids, are needed most.

The indirect liquefaction technique is so named because coal is first reacted with steam and oxygen (gasified to form a synthesis gas, mostly carbon monoxide and hydrogen, which is then chemically recombined to form liquids). The Fischer-Tropsch process converts the synthesis gas to a variety of liquid products such as gasoline, diesel fuel, and jet fuel as well as significant

quantities of methane-rich gas and chemical feedstocks. The famous Sasol plants in South Africa use Lurgi gasification and Fischer-Tropsch synthesis to produce commercial quantities of transportation fuels. The synthesis gas can also be made into methanol (wood alcohol) through well-proven technology. The methanol can be an end product itself or further processed to gasoline.

The direct liquefaction technique basically consists of mixing coal with a process-derived solvent. This slurry is mixed with hydrogen gas exposed to high temperature and pressure. Depending on the exact process, products can include a clean-burning solid fuel, liquid boiler fuels, liquefied petroleum gas, naphtha, and medium-Btu gas (which can be upgraded to high-Btu gas). Gasification is also involved in the processes to produce the needed hydrogen. While direct liquefaction is considered to be theoretically more efficient and economical than indirect liquefaction, indirect is commercially available today while direct is still in the developmental stage.

Gasification, or processes that emphasize gaseous fuel, is generally classified according to the heating value of the product gas--low-, medium-, or high-Btu. Low-Btu gas has a heating value of less than 200 Btu per cubic foot, medium-Btu has a value of 200 to 600 Btu per cubic foot, and high-Btu has values around 950 Btu per cubic foot, essentially equivalent to natural gas. All the processes react coal with steam and oxygen to produce gas. The resultant gas is usually mostly carbon monoxide and hydrogen which gives the gas its heating value. The first generation processes, as typically represented by Lurgi, actually produce a medium-Btu gas. This can be used as an end product or upgraded (methanated) to high-Btu gas. Low-Btu is produced in the same manner as medium-Btu except air is used instead of pure oxygen; this results in large amounts of nitrogen in the product gas giving it a lower heating value. Some of the newer processes, such as Hygas, produce relatively large amounts of methane directly in the gasifier.

Low-Btu gas can be used as a fuel but only at locations in the immediate vicinity of its manufacture. Because it takes about five times the volume of low-Btu gas to equal the heat value of natural gas, transportation costs quickly become prohibitive. Low-Btu can be useful, though, for manufacturers whose processes, such as kilns, consistently need large amounts of heat. Widespread use, however, would require many plants and extensive coal transporting.

Medium-Btu gas likewise can be used as a fuel but can be transported over a larger area than low-Btu gas. Estimates of how far medium-Btu can be economically shipped range from 100 to 200 miles. This could be adequate for a heavily industrialized area, but no pipeline infrastructures exist yet, even if plants were built. Again, extensive coal transport would be required if the industrialized area were not near mines.

High-Btu gas is interchangeable with natural gas. Thus, it can be commingled with natural gas and can use the nationwide network of pipelines that already exists. Plants can be located near coal sites, and just a few plants can use significant amounts of coal. One full-sized commercial plant will use more coal in a year than has been taken from the bigger mines in a like period. Also, current consumers of natural gas do not have to make any adjustments or equipment changes to use high-Btu gas.

Numerous processes exist or are being developed to produce the various gases. There are at least nine low-Btu gas processes commercially available for industrial applications. Three of these processes have been operated overseas for over 20 years, and each also has had at least one variation for producing medium-Btu gas. There are nine other processes which have been considered recently for medium and high-Btu gasification applications. The only process considered commercially available and readily amenable to high-Btu gas production is the Lurgi process. The only processes considered to have successfully completed pilot runs and to be able to perform demonstration by 1987 are Cogas, British Gas/Lurgi slagging gasifier, and Hygas.

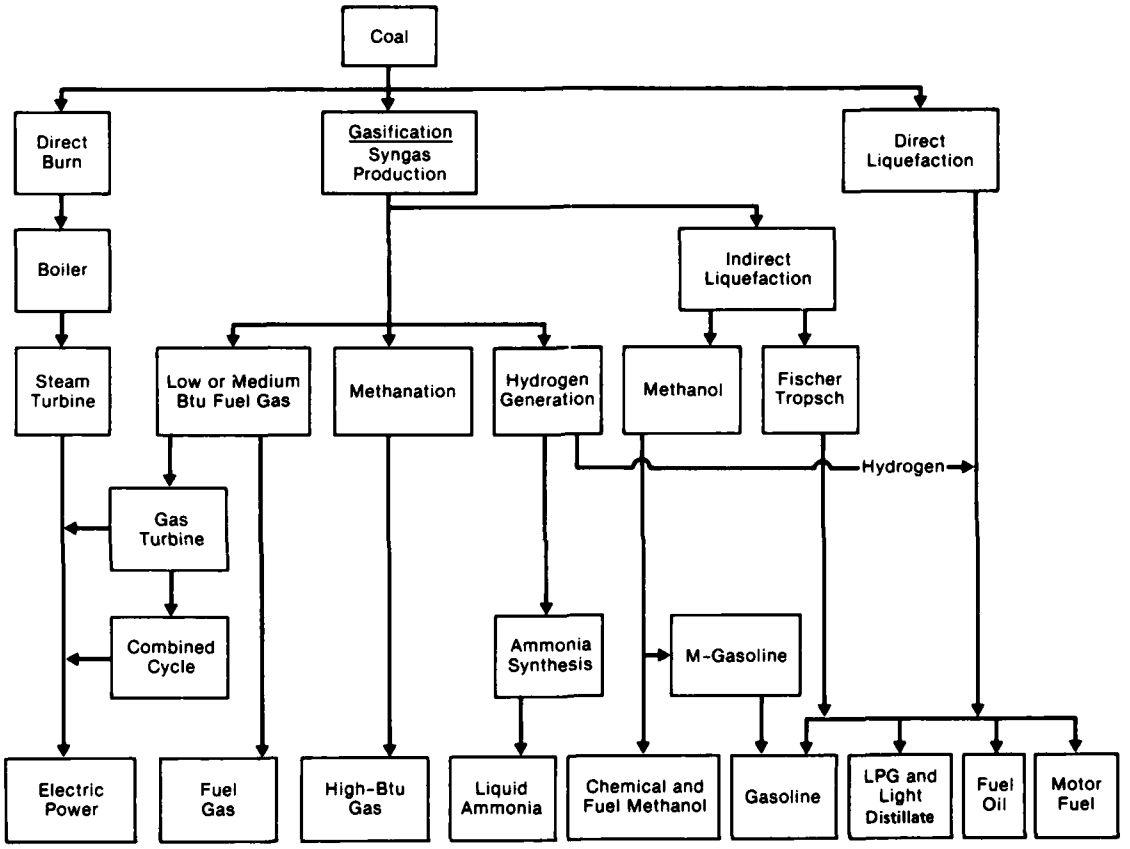
All three of the commercial projects included in our review plan to use first-generation gasification. Great Plains and Wy-CoalGas will methanate the medium-Btu gas produced to high-Btu gas for distribution. The Tri-State project puts the medium-Btu through the Fischer-Tropsch process to produce a variety of transportation fuels and chemical feedstocks in addition to high-Btu gas. Tri-State is actually an indirect liquefaction project, but high-Btu gas will make up slightly less than half the total plant output.

The three demonstration projects contacted use a variety of processes considered second generation, which purportedly are more economical and can handle eastern coals more easily than first generation. The Conoco project will use the British Gas/Lurgi slagging gasifier. It is essentially the same as first-generation Lurgi except it can operate at much higher temperatures with more throughput and can better accommodate caking coals. The ICGG project plans to use the Cogas process which is essentially pyrolysis combined with gasification of char. Both the Conoco and ICGG projects produce medium-Btu gas which is methanated to high-Btu gas. The ICGG project, however, also will produce significant quantities of liquid fuel byproducts since it does use pyrolysis. The Hygas process is essentially only for gasification of coal to high-Btu gas. Hygas uses a very high pressure gasifier which causes more methane formation in the initial processing. As a consequence, gas from the gasifier is higher in heating value than medium-Btu and needs less methanation to become high-Btu gas.

Apart from direct burn, high-Btu gasification and indirect liquefaction appear to be the only ways to use significant

amounts of coal with a few plants by 1987. Both use technologies which are or soon will be commercially available. There is a great deal of crossover between the two with some indirect processes producing large amounts of high-Btu gas and sharing technology with high-Btu gasification processes. The following chart shows the diversity of gasification and its products.

TECHNOLOGIES FOR USING COAL



STATUS OF SELECTED PROJECTS FOR HIGH-BTU GASIFICATION

To ascertain the potential for and obstacles to accelerated development of high-Btu gasification, we contacted six project sponsors. After mid-1980 discussions with officials of DOE, AGA, and GRI, we chose these six as "frontrunners" likely to be among the first high-Btu gas plants. Three of the six, Great Plains, Tri-State, and WyCoalGas, were designed as commercial plants; they would produce gas in quantities such that sponsors forecasted the plants to be profitable over their lifetimes. The remaining three plants, sponsored by ICGG, Conoco, and IGT (Hygas), were demonstration projects which were to show the technical, environmental, and economic characteristics of second-generation technology.

The sponsors' interests in the projects varied greatly. Among the commercial projects, Great Plains and WyCoalGas were directed almost solely at the development of a dependable gas supply. Tri-State, while planning a large gas product, was designed to produce large quantities of liquid synthetic fuels. Among the demonstration projects, ICGG focused specifically on Illinois energy needs, Conoco was interested in marketing its coal, and IGT wanted to develop its Hygas technology.

The adequacy of the intended sites for full-sized plants depended on whether the projects were commercial or demonstration. All three commercial projects had acquired options, had options, or were pursuing options on sites suited for full-sized plants even where the proposed plant was to be built in stages. Among the demonstration plants, only Conoco had a site adequate for possible expansion to a commercial plant and only a small one at that. ICGG had not yet acquired the chosen site, and it would not have been suitable for any commercial-sized facility. IGT had not selected a final site although it hoped to have one adequate for commercial expansion. The projects' sites and coal types varied greatly. Great Plains was to be located in North Dakota and use lignite as its coal feedstock. WyCoalGas' site was in Wyoming, and the coal is subbituminous. Both the preceding projects' coals are western, low-sulfur, noncaking types. The remaining four projects planned to use eastern, high-sulfur, caking coal. Tri-State planned a Kentucky site using Illinois basin bituminous coal. IGT's Hygas tentatively planned a Kentucky site using similar coal. ICGG planned an Illinois site using Illinois No. 5 and No. 6 coal which are specific types of Illinois basin bituminous coals. Conoco planned an Ohio site using No. 9, an Appalachian bituminous coal. Among the eastern coals, Illinois basin coals range from weakly to highly caking, while the Ohio No. 9 is highly caking.

Plant sizing also varied among the projects. The commercial projects were all designed as full-sized plants, although

Great Plains and WyCoalGas both intended to build only half-sized plants for their initial effort. The demonstration plants basically consisted of one module. The IGT plan called for the Hygas module to be full scale so a commercial plant could be built at the same site by replicating that module. Both the Conoco and ICGG plans were for less than commercial scale so the modules would have been of little use in expansion to commercial-sized plants even if the sites were large enough.

The level of technological development ranged from operating commercial plants to very small pilot plants. All the commercial projects were based on the proven first-generation Lurgi gasifiers. In particular, Tri-State was essentially a copy of a full-sized plant producing liquid fuels in South Africa. The basic technological questions pertain to the production of high-Btu gas, which has not been done commercially, and the operating characteristics of American coal types. The demonstration plants all planned to use second generation technology which was based on pilot plant operations. ICGG was to use the Cogas process which consists of a pyrolysis unit piloted in the United States and a gasifier unit piloted in England. The units have never been run in tandem as they would at the demonstration plant. Conoco was planning to use the British Gas/Lurgi slagging gasifier piloted in Scotland. Although this pilot gasifier worked well on some coal, there is a question concerning its effectiveness using the coal Conoco intends. IGT's Hygas process had been extensively piloted in the United States, but the demonstration plant would have design changes from the pilot as a result of scaling up the gasifier.

Financing arrangements can be a stumbling block for all the projects. The estimates of capital and gas cost vary widely for the commercial projects depending on a variety of factors. All agree, however, that capital will be huge and the gas cost relatively high. All the commercial projects assume the Government will guarantee the debt portion of capital. Some may also need price supports. The demonstration plants, as they were conceived, would all need heavy Government financial involvement. The Government had funded virtually all the design phase of the ICGG and Conoco projects, as well as provided funds for a nonsite-specific Hygas design.

The projects were at various stages in environmental planning. Great Plains had an approved EIS, WyCoalGas had an early environmental assessment report which had been updated to prepare an EIS, and Tri-State was developing an environmental assessment report for the EIS. Among the demonstration projects, Conoco and ICGG were well along towards completed EIS's, but DOE was holding back until the Federal funding picture had become clearer. IGT had no final location for Hygas and thus could not begin developing information for an EIS which is site-specific. None of the sponsors foresaw any environmental "showstoppers," but the full effect of the Toxic Substances and Control Act (TSCA)

and the Resource Conservation and Recovery Act (RCRA) remains to be seen.

Summaries for each of the six projects follow. GAO prepared the summaries which project sponsors reviewed for accuracy as of May 1981. The summaries were updated based on information from DOE which pertained to the period through September 1981.

GREAT PLAINS COAL GASIFICATION PROJECT

A group of natural gas companies are sponsoring a commercial-sized coal gasification plant in North Dakota as an alternative source of gas for their pipelines. During the last several years, this project has been in the forefront of U.S. efforts to develop synthetic fuels. The leading sponsor, American Natural Resources Company (ANR), has acquired coal options, land, water rights, environmental clearance, and a detailed design for the plant. The most persistant obstacle, jeopardizing the project since 1975, the absence of a financing package acceptable to the sponsors, the lenders, the gas customers, and the Government, has been overcome. As a result, the project will get the loan guarantee it needs from DOE, once final negotiations are completed. These negotiations are expected to be completed in early 1982.

Sponsors seeking natural gas substitute

Around 1970, ANR, supplier of pipeline gas to nine midwestern States, became interested in coal gas as a substitute for dwindling reserves of natural gas. During the first half of the seventies, it chose a process and a site for a plant; secured coal, land, and water; and began work on a design. In 1975 ANR presented the Federal Power Commission (now FERC) with a proposal to finance the plant with tariffs on its gas customers. While the commission was considering this proposal, ANR added some cosponsors. Currently, four companies, whose pipeline subsidiaries serve a substantial portion of the Nation's gas customers, are offering to share the plant's cost and production: ANR; Peoples Energy Company; Tenneco Inc.; and Transco Companies, Inc. However, only ANR and Peoples have so far contributed any funds to the project.

Although the natural gas supply picture looks considerably better than it did a decade ago, ANR believes coal gas will still be needed in the long run. Officials now view the Great Plains project as a demonstration of technology--the foundation for a future coal gasification industry. ANR has identified several sites for coal conversion plants near its North Dakota reserves, which are sufficient to support several plants the size of Great Plains. It also has extensive coal reserves in three Eastern States.

Site chosen for available coal

ANR selected Mercer County, North Dakota, for its plant site after locating nearby reserves of inexpensive lignite, a low-grade coal which is gasifiable by a commercially proven process. ANR purchased options to buy 4 billion tons of this coal.

The site is 535 acres in a sparsely populated area. Rights have been obtained to draw water from a nearby reservoir.

Mercer County is rather remote from the sponsor's pipelines. The sponsors plan a 45-mile connnection to the Northern Border Pipeline which should be in service by the fall of 1982 and which will join with their existing pipelines.

Full-sized plant to be achieved in two steps

ANR's original proposal was for a plant that would produce 250 million cubic feet of gas a day. However, delays in obtaining an acceptable financing package caused costs to rise, so ANR decided to build a half-sized plant initially, and add the second half later. This proposal envisions an operational plant by 1984.

The half-sized plant will require 20,000 tons of coal a day. Besides 125 million cubic feet of high-Btu gas per day, it will produce sulfur, ammonia, and coal fines too small for gasification. The coal fines will be sold to an adjacent electric powerplant. Other byproducts are possible if future EPA regulations can be satisfied and byproduct market conditions improve.

The plant will use the Lurgi gasification process, commercially established in several plants abroad. ANR had one of these plants run tests in North Dakota lignite and used the data in designing Great Plains.

Absence of an acceptable financing package

Since 1975, ANR's stumbling block has been the inability to arrive at a satisfactory package for funding the plant's construction and profitable operations. From the beginning, it proposed to contribute one-fourth the cost of construction and finance the rest with a Government or ratepayer-guaranteed loan. In an earlier proposal, interest on the loan and a return on ANR's investment would be paid through a surcharge on its gas customers while the plant was under construction. This surcharge would apply even if the plant was never finished. The rest of the costs would be paid through the sale of the coal gas at a price that would be averaged into the price of the sponsor's gas from other sources.

The proposal was first rejected by an administrative law judge. ANR appealed, and by 1980, FERC had approved the surcharge and the pricing arrangement, and DOE had offered a loan guarantee. By this time, ANR had spread the cost burden among 30 percent of the Nation's gas consumers by adding cosponsoring pipelines and lightened that burden by halving the plant's initial size.

However, some of these customers were unwilling to bear the construction costs of Great Plains in their gas bills. They reasoned that the plant would contribute only a small amount to their supply of gas, and very expensively. Since the project seemed justified more from a standpoint of national interest than from one of gas supply, they felt it should be financed by the taxpayers. Consequently, General Motors Corp. and three State consumer agencies filed suit to stop FERC from implementing ANR's proposal. The court overturned the financing package by ruling that FERC had no authority to exercise direct jurisdiction over the manufacture of synthetic gas, prior to its commingling with natural gas.

ANR and the other project sponsors then negotiated with the opposing parties, hoping to reach an acceptable financing package. On April 30, 1981, FERC issued Opinion 119 which allows the plant's gas to be sold at a "fixed price" of $6.75 per million Btu, adjusted for inflation and increases in the cost of a competing fuel. Under this order, the project sponsors will assume all equity risk, and there is no surcharge either during construction or in the event of abandonment.

Latest cost estimates for the first half of the plant, capital plus startup costs, are $2.4 billion. With contingencies and a pipeline included, the total financing commitment being arranged is $2.7 billion of which over $2 billion (75 percent) would be covered by the Federal loan guarantee.

Final EIS issued

DOE issued a final enviromental impact statement on Great Plains, after various Federal agencies had studied the plant's potential effect on its surroundings. ANR officials feel confident they have anticipated and resolved all environmental problems. The plant is designed to meet the strict standards in force in North Dakota. The project has acquired most of the 40 Federal, State, and local permits needed; some of these may have to be renewed by the time construction begins.

ANR officials estimate they have spent $2 million directly on environmental testing. According to a 1978 DOE study, the plant's pollution control will absorb 9 to 16 percent of capital costs and 13 percent of operating costs.

Also, assuming Great Plains will be the Nation's first commercial coal gas plant, DOE says the Government will need

environmental data beyond that necessary for compliance with regulations. ANR has proposed that the Government fund this research. DOE has so far given ANR $25 million, partly to design a wastewater system for the plant, under a cooperative agreement that helped keep the project afloat during 1979-80. This money is to be refunded to DOE if the plant is built.

ANR plans to burn certain potential byproducts in the plant's boilers due to poor market conditions and environmental considerations. If EPA decides these byproducts are safe and market conditions improve, ANR might market them.

The project would draw numerous laborers to sparsely populated Mercer County, many of whom will leave once construction is finished. ANR is working with State and local authorities to mitigate the adverse impacts that such fluctuations could cause. Phased construction of the gasification plant and a complimentary schedule for two nearby powerplants will help.

WYOMING COAL CONVERSION PROJECT

Panhandle Eastern Pipe Line Company, a major supplier of natural gas to the Midwest, is trying to build a commercial coal gasification plant to provide an alternative source of gas. Wyoming has been chosen for the site because its coal reserves can be strip-mined, a portion of which Panhandle has already acquired. The plant, to be built in two overlapping stages, will convert 32,600 tons of coal to 300 million cubic feet of high-Btu gas daily.

The financing of the plant is largely unsettled so cost estimates are not well defined. The company must also update their environmental assessment and write an impact statement. Plans were to spend $28 million through 1982 under a cost-sharing agreement with DOE.

Need for alternative source of gas

In the late 1960s when natural gas consumption began to exceed newly discovered reserves, Panhandle Eastern, supplier to five midwestern States, began considering alternative sources. (Although new supplies are currently catching up, Panhandle believes they will prove inadequate in the long run.) During 1973-74, Panhandle acquired coal, land, and water in Wyoming, developed a preliminary design, and established a subsidiary--WyCoal Gas, Inc.--to manage the project. Panhandle's partners in the Wyoming project had been Pacific Gas and Electric, a northern California utility, and a U.S. subsidiary of Ruhrgas AG, a West German pipeline company.

Besides the Wyoming project, Panhandle was cosponsoring a slagging gasifier demonstration (see p. 87) and participating

in a consortium that owns the Cogas process, which was to be used in a demonstration project in Illinois (see p. 89). Thus, Panhandle was involved in three of the high-Btu projects covered in this review.

Coal resources motivated site choice

Panhandle chose a rural area of eastern Wyoming for its plant because of the availability of strip-mineable coal. A possible Illinois site was rejected because coal there would have to be deep mined, a more expensive proposition. Panhandle and the Peabody Coal Company co-own a 500 million ton reserve near the site.

While coal reserves are ample, water for the plant has been more difficult to obtain in this dry region. The plant can draw part of its water from the North Platte River. Therefore, the sponsors will create a reservoir to store excess river water during periods of high flow. Second, WyCoal Gas helped the local irrigation district repair a deteriorated dam and in exchange received rights to purchase a portion of the district's increased capacity. Third, the sponsors will drill wells. Lastly, the plant will recycle all process water and storm water collected, not only to conserve, but also to avoid any water pollution emissions.

A problem yet to be resolved was the site's remoteness from large markets for high-Btu gas. Panhandle's options were to build a 475-mile connnection with its own pipeline in Kansas or to connect with other firms' pipelines nearer the plant.

Commercial plant to be built in stages

The sponsors believe their design will prove successful. The plant's main gasifiers will be the Lurgi Mark IVs, already proven commercially in the South African Sasol plant. The sponsors sent Wyoming coal to Sasol for tests to determine the exact byproducts. The project's design, however, envisions recycling many of the Lurgi gasifiers' byproducts through Texaco gasifiers to convert them to gas, thus avoiding potential conflicts with the TSCA. Texaco studies indicate its gasifiers will work as planned.

The sponsors intend to build their plant in two overlapping stages, each with a capacity of 150 million cubic feet of gas per day. They had hoped to begin stage I in 1982, have it start up by 1986, and bring stage III on by 1988. The completed plant will consume 11 million tons a year of subbituminous western coal, a coal suitable for direct burning. Byproducts not recycled through the Texaco gasifiers will include sulfur, ammonia, and coal fines to be sold to area powerplants.

The sponsors estimated the high-Btu gas produced would cost about $4 per million Btu in 1979 dollars. This estimate was only preliminary and did not include some important elements. A later estimate indicated the gas cost would be two to three times as high.

Government funding guarantees envisioned

Funding construction will require Government-guaranteed loans. The sponsors also expect to get a FERC tariff which would set a given price rather than be based on cost of service. They currently are sharing with DOE the costs of engineering and design.

In September 1981 WyCoal Gas and DOE signed a modification for the mutual termination of the cost-shared agreement with only about 50 percent of the work complete. While some environmental work was to continue until March 1982, WyCoal Gas terminated the agreement and slowed its project development because it had been turned down on a DOE loan guarantee application, it received no encouragement on the early resolve of a like SFC application, and its two partners withdrew from the project.

Under the 1980 agreement, DOE would have provided $13 million. The amount provided was repayable with interest if the project advanced to construction. In addition, WyCoal Gas was to have spent about $28 million on the project during the design phase, for example, on the test at Sasol. Panhandle and its subsidiary had already invested $18 million in the Wyoming project.

Building stage I would cost an estimated $2.7 billion in 1980 dollars escalated for inflation at 10 percent per year. The estimate includes a contingency of 20 percent. The sponsors had planned to contribute one-fourth of the cost and borrow the rest under a Federal guarantee. They also expected to ask FERC for a tariff and had applied for price guarantees from the SFC but had not yet quantified the amounts.

Environmental assessment being updated

Panhandle is updating its 1974 environmental assessment to account for changes in the design and in regulatory requirements. Officials estimate environmental testing will cost $4.3 million and environmental controls will cost $81.1 million. They feel confident that requirements will be met.

Since all water used will be recycled, there will be no liquid discharge. The absence of information of TSCA's impact resulted in the addition of Texaco gasifiers to eliminate certain byproducts. Once TSCA standards become clear, these byproducts may be marketed and the Texaco gasifiers can be used to gasify coal fines.

TRI-STATE SYNFUELS PROJECT

The Tri-State Synfuels project is to be a commercial-sized plant that will produce a variety of synthetic fuels from coal, including high-Btu gas beginning in 1987. The sponsors, affiliates of Texas Eastern Corporation and Texas Gas Transmission Corporation, own large coal reserves and pipelines near the proposed site, northwestern Kentucky near the Illinois and Indiana borders. They plan to spend over $40 million through 1983 to design and engineer the plant under a cost-sharing agreement with DOE. Once the design is complete, they intend to finance about one-fourth of the plant's $3.5 billion 1980 construction cost with their capital, and the rest with loans guaranteed at least partly by the Synthetic Fuels Corporation.

The plant will be similar to one already operating in South Africa, so technical risks are considered minimal. It will convert high-sulfur, moderately caking coals into about 321 billion Btu of fuels and chemical byproducts a day, of which high-Btu gas will comprise somewhat less than half, and liquid fuels and chemicals the rest.

Experienced sponsors' interest in variety of synfuels

Texas Eastern Synfuels, Incorporated, the project manager, is a subsidiary of Texas Eastern Corporation, a diversified energy company. Texas Eastern has extensive natural gas pipelines to both the East and West Coasts and petroleum products pipelines to the Midwest and East Coast. They also explore for and produce oil and gas, market petroleum products, and operate a crude oil refinery and gas processing plants. Texas Eastern has been researching a variety of synthetic fuels from coal since 1962, participating in such projects as:

--Wesco project (1970-1978) to build a coal gas plant in New Mexico. Texas Eastern managed this project, which failed because federally guaranteeed loans were unavailable and a site lease had been hard to obtain.

--The Westfield methanation project (1972-75) which demonstrated the commercial feasibility of enriching medium-Btu gas to make high-Btu gas.

--A 1974 feasibility study for an Illinois coal gas plant.

--The Westfield slagging gasifier development program (1975-77). Texas Eastern is currently involved in four other proposed synthetic projects.

--The New Mexico project (an outgrowth of Wesco) and the Lake Desmet project, both to produce high-Btu gas and methanol from coal.

--The Paraho oil shale module project.

--A slagging gasifier demonstration in Ohio.

Officials attributed the firm's interest in synthetic fuels to its need to keep its pipelines supplied, as well as the Nation's need for alternatives to natural gas and oil. The Tri-State project was inspired by developing legislative support in Washington which appeared to make financing such projects feasible.

The other industrial partner, Texas Gas, also has natural gas pipelines to the Midwest, as well as barge and truck operations, and large coal reserves near the site. More industrial partners will probably be added later to share expenses.

Site picked for resources and markets

The proposed site, Henderson County, Kentucky, is convenient to both resources and markets. The site consists of approximately 6,000 acres, but only about 2,000 are useful because most of the rest lies within a flood plain. The plant proper will occupy about 1,500 acres; a portion of the remainder will be used for effluent treatment and waste disposal and storage. Texas Eastern has not purchased the land yet. Rather, the State of Kentucky is purchasing options to buy, which it will resell to Texas Eastern at cost if the plant is built. The land is currently used for farming and pasture and includes a small airport that will be relocated. The Ohio River can supply ample water as well as transportation.

Texas Gas owns 300 million of recoverable coal in the area, and 5.5 billion recoverable tons are buried within 50 miles, according to the sponsors' consultant. Both sponsors have pipelines nearby; Texas Eastern's gas pipeline serves Pittsburgh, Philadelpha, Newark, New York City, and points along the way. In addition, officials cited acceptable air quality standards, a cooperative State government, and local acceptance as reasons for choosing the site.

Project is a full-sized commercial plant

Tri-State will be a full-sized commercial plant designed to produce a wide range of liquid fuels as well as high-Btu gas. Current plans call for 36 Lurgi gasifiers in 4 trains. Unlike some other projects, the sponsors have no intention of building the plant in stages, primarily because the economics of a refinery for the liquid fuels would be adversely affected with a smaller plant. According to officials, a half-sized plant would save 40 to 45 percent in construction costs and could be limited to high-Btu gas and synthetic crude oil that would have to be transported to a refinery elsewhere.

The precise mix of products will be determined as a result of a detailed market study to be conducted in 1981. A preliminary market study was completed in April 1980. Tentatively, the plant's output will consist of 321 billion Btu's per day, the equivalent of about 56,000 barrels per day of crude oil. The plant's production will include high-Btu gas, gasoline, jet fuel, diesel fuel, heating oil, and liquified petroleum gas (propane and butane), with the balance in chemicals. Chemical byproducts tentatively include various alcohols, ethylene, creosotes, sulfur, and ammonia.

A very early estimate is that the products will cost an average of $7.75 per million Btu in 1980 dollars. This estimate does not necessarily relate to the cost of any specific product since it merely spreads the early total cost estimates over the heating value of all outputs, including byproducts. The sponsors will allocate the cost of production among the different products during the detailed design phase. The products are expected to be economically competitive over the plant's life, but probably not during the first few years of operation.

To generate these products, the plant will consume about 28,500 tons of coal a day, or 260 million tons over its 25-year life. The intended coal is moderately caking eastern bituminous coal whose sulfur content, more than 3 percent, makes it undesirable for direct burning. It will come from deep mines in the Illinois Basin.

Financing is the chief obstacle

Financing construction of the Tri-State project may require both Government loan guarantees and price support. The sponsors' preliminary estimate of the plant's cost was $3.5 billion in 1980 dollars. Inflation and interest on funds borrowed during construction could double the cost by 1987, when they hope to complete the plant.

As of January 1981, the sponsors have already spent several million dollars on the project. The Department of Energy will advance the sponsors $22.4 million during 1981-83 under a cooperative agreement signed in February 1981 for a detailed design and engineering plan. The sponsors will more than match this amount and will reimburse the Department of Energy advance during the early years of operation.

During the construction phase, the sponsors expect to contribute about 25 percent of the capital cost and borrow the rest. Officials believe a Government loan guarantee will be needed. The Congress, however, has limited SFC loan guarantees to $3 billion for any single project, which would not cover 75 percent of the escalated Tri-State Project cost. However, officials will pursue alternatives to cope with this limitation, including

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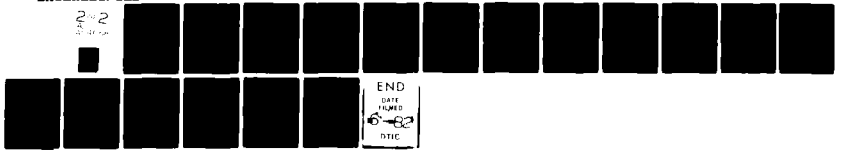

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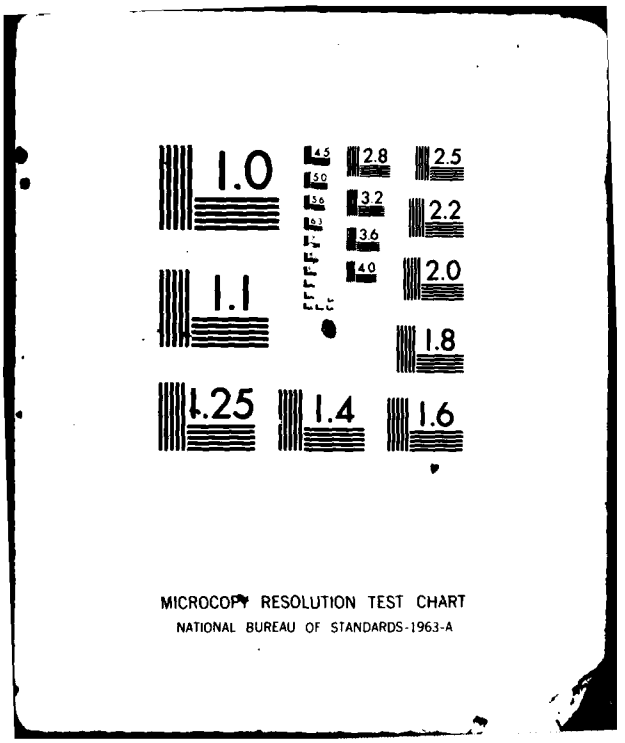
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loans arranged with less than a 100 percent Government guarantee. They do not plan to ask FERC for a rate hike to finance construction. Determination of any need for price supports during the first few years of plant operation will be made during the detailed design phase when definitive cost estimates and market studies will be completed. The primary products are expected to compete more easily with imports than with domestic products.

The high plant cost is a bigger obstacle to be overcome than any technical problem. Tri-State's design is a copy of the Sasol II plant, which began operating commercially in South Africa in 1980. Thus the only major technical uncertainty is the design modifications required to gasify Illinois Basin coal. This coal has passed test runs in a similar Lurgi gasifier. To get more reliable data for the model of gasifier used in Sasol and Tri-State, the sponsors have contracted with Sasol for full scale tests of Illinois Basin coal in the summer of 1981.

EIS still to be developed

The sponsors expect to have an environmental impact study by 1982. They are now conducting field studies and monitoring. Though both EPA policy and the plant's emissions are still uncertain, the sponsors anticipate no insurmountable obstacles.

A major uncertainty is how the Toxic Substances Control Act will bear on the plant's numerous products. The sponsors do not know whether EPA will accept these products as identical with known commercial compounds or will require extensive new-product tests, possibly involving 2-year animal studies, to determine toxicity.

The project's location may make air pollution and waste disposal requirements easier to meet than they might be elsewhere. The air quality in the surrounding area meets EPA standards, so Tri-State will not need to get emission reductions from other dischargers to offset its emissions. Secondly, Kentucky may open a State disposal site for hazardous wastes, obviating one at Tri-State.

The sponsors expect to undertake numerous environmental tests and studies within the next few years at a cost of a few million dollars. The coal test at Sasol is also expected to yield a great deal of environmental data. Also still to be obtained are a multitude of Federal, State, and local permits.

Nevertheless, the sponsors believe pollution control technology for the plant is commercially available and already proven. Sasol has estimated that meeting U.S. environmental standards will take 525-700 million in 1980 dollars, or 15 to 20 percent of the plant's cost. Although sponsors expect environmental standards to change, they foresee no "show stoppers."

CONOCO DEMONSTRATION PROJECT

The Department of Energy contracted with Conoco, a corporation with large energy interests, to design a demonstration plant using a technology that promises to gasify strongly caking, low-reactivity coal at rates exceeding those of conventional gasifiers. Conoco owns a large supply of such coal and is interested in developing a market for it. DOE was expected to decide in July 1981 whether to go ahead with construction of the demonstration plant, which would have been completed in 1984. However, Federal funds appropriated for a demonstration were rescinded in June 1981.

The plant was to use primarily Ohio No. 9 coal, whose high-sulfur and ash content has so far made it virtually unmarketable. Conoco owns enough of this coal at the plant's southeastern Ohio site to support a small commercial plant and was considering building one there if the demonstration proved successful. Originally, the demonstration project was planned as a commercial-sized module, but to cut costs Conoco reduced it in size and scale; thus it would not have been of much use as a part of the potential commercial plant.

DOE fully funded the demonstration plant's design and intended to split the construction and operation costs with the sponsors. The administration, however, proposed ending DOE funding of the plant after the design phase and the Congress concurred. The company has not yet decided whether to build a plant without DOE support.

Sponsor seeking a coal market

Conoco has been researching coal gasification for 30 years. Currently, besides the demonstration plant in Ohio, the firm is involved in feasibility studies of commercial coal conversion projects in Louisiana and Utah.

This interest stems from Conoco's coal reserves--the largest privately held in the United States. Also a major oil company, Conoco advertises planned 1981 investments in exploration and plants of $3 billion. Officials said they would like to have one or more synthetic fuel plants well along by 1990.

Conoco's coal holdings include large reserves of Ohio No. 9 in southeastern Ohio. This coal contains substantial sulfur and ash, making it undesirable for direct burning, and it is unsuitable in first-generation gasifiers. Conoco also owns vast quantities of Pittsburgh No. 8 coal, which likewise is strongly caking and has low reactivity at conventional gasification temperatures.

These holdings largely explain Conoco's interest in a slagging gasifier. During 1974-77, Conoco coordinated 13 U.S. industrial firms that financed a slagging gasifier pilot

plant built in Scotland by British Gas Corporation. The results led Conoco to propose a demonstration project in response to ERDA's solicitation.

Besides Conoco, the demonstration had 10 industrial co-sponsors, including 6 gas pipeline companies.

Site would support small commercial plant

The Ohio No. 9 coal on the site is sufficient to support a small commercial plant, producing 100-125 million cubic feet of gas a day. Conoco officials said they would consider building such a plant, to be completed sometime after 1992, if the demonstration succeeded. Their contract with DOE, though, entailed projecting the demonstration results to show the requirements of a large commercial plant producing 241 million cubic feet. The site contains insufficient coal for a plant of this size. Otherwise, the needs of a large commercial plant could probably be met at the site. Two of the cosponsors have pipelines in the vicinity.

Project scaled below commercial module

Although Conoco orginally planned the demonstration plant as a full-sized module of a possible commercial plant, it later judged these plans to be too costly. Consequently, it cut the number of gasifiers from four to two, and reduced the scale of the other equipment. Except for the gasifiers, much of the demonstration plant might have been discarded in the event a commercial plant is built on the site since the designed demonstration plant could not have produced gas at a competitive price.

The plant would have differed from first-generation coal gas plants chiefly in the design of the gasifier, a substantially modified version of the conventional Lurgi gasifier. The slagging gasifier operates at a high temperature. This overcomes the low reactivity of eastern coal and melts the ash to [illegible] a molten slag. Temperature is much greater than in conve[illegible]al dry ash gasifiers so the coal gasifies at a faster rate [illegible]co officials expect the slagging gasifier to operate at four to six times the rate of a conventional gasifier. The demonstration plant, with one operating gasifier and one spare, was designed to convert about 1,250 tons of coal to 19 million cubic feet of high-Btu gas a day. A commercial plant using 12 slightly larger gasifiers (including 3 spares) would turn out 241 million cubic feet a day. Byproducts would have included tar oil, sulfur, ammonia, and naphtha.

A second advance the plant would have demonstrated was the consolidation of two steps in the production of high-Btu gas:

shift and methanation. Project engineers believe they could save $1 per million Btu of gas by performing the two steps in one unit.

Conoco officials believe both these innovations will work. A slagging gasifier about one-third the scale of the demonstration plant's was tested on both Ohio No. 9 and Pittsburgh No. 8 coal at the pilot plant in Scotland. During 1977-78, tests on Pittsburgh No. 8 were successful, although unwashed Ohio No. 9 performed poorly. After further tests, however, British Gas told Conoco that Ohio No. 9 performs well when washed. Although British Gas has not released the latest test data, Conoco officials have confidence in its assurances. Should Ohio No. 9 not work out, however, they said they could fall back on Pittsburgh No. 8, which could be transported to the site. (Besides these two coals, Conoco agreed to test a third, unspecified coal for DOE.) As for the combined shift and methanation, Conoco believes the process is fully tested, although it has yet to be used commercially.

Despite the increased productivity from the slagging gasifier and the combination of shift and methanation processes, the cost of the gas produced (in 1980 dollars) would be $18.91 per million Btu, much higher than a marketable price. A commercial-sized plant, however, would produce gas at $6.43 per million Btu, Conoco estimated, and it hoped to sell the demonstration plant gas at about that price.

Cost sharing became an obstacle

While DOE agreed to fund the plant's design at $38 million, the sponsors were expected to share equally in the costs for construction and operation, a total of $425 million in 1980 dollars. Later, the sponsors wanted to change the cost sharing terms. They wanted credit toward their share for certain prior expenses. However, DOE stopped discussions on this proposal because of the impending rescission and only wanted Conoco to complete the design phase.

Conoco officials expressed dissatisfaction with DOE's handling of the project. Considering delays on funding the demonstration plant and management problems they have encountered on another project, they would be reluctant to get involved with the Government in another synthetic fuel project. They would rather pursue such efforts independently. They endorsed the administrations' decision to terminate the project, saying that time had eroded the demonstration's usefulness.

EIS well along

Conoco submitted an environmental assessment to DOE in early 1980. DOE drafted an environmental impact statement, but it withheld publication for comment, pending a decision on the funding of plant construction. Although the demonstration plant needed

numerous Federal, State, and local permits, Conoco anticipated no difficulties, except possibly with RCRA and TSCA.

Although standards for RCRA have yet to be issued, Conoco planned to go ahead with construction and make modifications later if necessary. Officials believed such modifications would be minor.

TSCA presented a similar situation. Although Conoco expected the plant's byproducts to be identical with commercial petroleum compounds, EPA may have disagreed and required up to 2 years of tests. In that event, Conoco officials said they would consider recycling the compounds by burning them in the gasifier.

Conoco had spent $1.4 million for environmental testing and permit acquisition through early 1980. Conoco officials felt they could not estimate the ultimate cost of pollution control at the plant, since much equipment designed for pollution control functions had other purposes as well.

ILLINOIS COAL GASIFICATION DEMONSTRATION

Subsidiaries of five Illinois gas companies, the Illinois Coal Gasification Group (ICGG), proposed a demonstration of the Cogas process, which can convert eastern coal into high-Btu gas and liquid fuels. The Department of Energy agreed to fund most of the plant's design, costing an estimated $60 million. The sponsors would have liked DOE to fund most of the $636 million construction and operation phases as well, but DOE did not commit itself since funding was being withdrawn from the program.

If built as planned, the demonstration plant would have been about one-fourth the scale of a commercial module. The sponsors refrained from a full-scale module because they felt the additional investment would not resolve a commensurate amount of technical uncertainties and might hurt their position in competing for DOE funds. Their contract with DOE, however, included a conceptual design for a commercial-sized plant, and they would have considered building one if the demonstration succeeded technically and economically and if market needs dictated such action.

State inspired group to use Illinois resources

Prompted by a widening gap between gas demand and supply in the early 1970s, the Illinois Commerce Commission ordered that State utilities combine efforts to study the feasibility of converting Illinois coal into a supplemental gas supply. The eventual result was the ICGG, which responded in 1975 to an ERDA request for proposals to build a high-Btu gasification

plant. Considering the present natural gas supply situation, ICGG officials feel coal gas is still needed, though not as urgently as it once seemed.

Two of the project's five sponsors are subsidiaries of large energy companies. Peoples Energy Corporation is involved in two other gasification projects, a liquified natural gas project, oil and gas exploration, and coal mining. NICOR, Inc., is likewise exploring for gas and oil and mining coal.

Site not yet acquired

ICGG had chosen a site for the demonstration plant, but it had not negotiated the purchase. The 400-acre site was a former strip mine only partially reclaimed. The site considered for a commercial plant would encompass 1,300 acres of similar land nearby.

The area, Perry County in southern Illinois, provides transportation to markets, including a natural gas pipeline 11 miles away and rail and truck lines for byproducts; water from the Mississippi River; and plentiful coal. The demonstration plant and the prospective commercial plant would have used Illinois Nos. 5 and 6 coal, eastern, bituminous, high-sulfur coal. Perry County contains enough recoverable coal to supply three commercial plants. Besides Illinois coal, the DOE contract may have required the plant to test Pittsburgh No. 8 and Wyoming subbituminous coals.

Project designed below commercial scale

A commercial plant would have three trains, with each train about four times the scale of the demonstration plant. Although the demonstration plant represented a 30-fold scale-up from a pilot plant that tested the gasifier to be used, the sponsors did not consider the dimensions an element of high risk. They rejected proposing a commercial-scale module in response to the DOE solication because:

--The additional uncertainties that would be resolved would not be worth the additional investment.

--To compete for DOE demonstration funds, they needed to keep the Government's cost down.

Additionally, they had considered the project from the objective of demonstrating the technology, not as a step towards commercial production. The sponsors stated that if the project failed to receive DOE funding for construction, they would consider whether their project would meet criteria for SFC funding. However, ICGG is not considering a scale-up to commercial size in the near

future as there is no immediate need for gas. Thus, consideration of placing this project in the SFC would be solely for demonstration purposes.

The plant was to demonstrate the Cogas process, which has several unique features:

--It uses air, rather than pure oxygen, eliminating the need for an oxygen plant.

--The first step in the process is pyrolysis, the heating of coal in the absence of oxygen to produce raw gas and granular char, a residue composed of carbon and ash.

--The granular char is gasified in a "fluidized bed" which keeps it afloat with steam. Conventional gasifiers cannot handle granular material, so coal fines present a problem of disposal.

--The raw gases from pyrolysis and from char gasification are refined to produce high-Btu gas and large amounts of liquid byproducts.

The two major steps in the Cogas process--pyrolysis and char gasification--have never been combined before, although both have been tested separately in pilot plants. Other areas of risk included the combining of two gas processing steps and waste water treatment. Overall, though, the uncertainties entailed in process integration and scale-up were not out of the ordinary for a new type of plant.

The demonstration plant would have converted 2,200 tons of coal a day to 23 million cubic feet of high-Btu gas, 1,400 barrels of fuel oil, 400 barrels of naphtha, 4 tons of ammonia, and 60 tons of sulfur. A conceptual commercial plant, as designed, would convert 26,000 tons of coal to 250 million cubic feet of gas, 17,000 barrels of oil, 4,000 barrels of naphtha, 50 tons of ammonia, and 700 tons of sulfur.

A 1976 estimate placed the cost of gas from the demonstration plant at $11.25 per million Btu. The sponsors acknowledged their gas would be far too expensive to be sold profitably and competitively, but that was not the purpose of a demonstration plant. According to a 1978 estimate, the commercial plant would produce gas at $6.42 per million Btu, after taking credit for the sale of the byproducts. This estimate would probably be much higher today, since by 1980, capital costs alone had risen by almost half. However, this increase would be partially offset by the increase in the selling price of byproducts.

Cost sharing a question mark

Under the original proposal, ICGG was to split the costs;

however, these costs rose from $271 million to $636 million. Meanwhile, the outlook for new natural gas discoveries improved. Furthermore, the Illinois Commerce Commission recently questioned the appropriateness of customer support for coal gas plants. Thus, in March 1981, the ICGG sponsors notified DOE that they would no longer offer to proceed to construction under 50-50 cost sharing because they believed the Federal Government should bear the major share of the demonstration plant costs. However, DOE would not renegotiate because of the impending program budget rescission.

EIS well underway

Meanwhile, DOE held up processing of the environmental impact statement until the plant's fate was decided. Public hearings on the EIS were supposed to take place in February 1981 with final publication in May. The sponsors were also awaiting Illinois EPA approval of their arrangements to prevent significant air quality deterioration.

Although the sponsors would have needed numerous permits, they anticipated possible difficulties only with two Federal laws for which EPA has yet to issue final standards. RCRA restricts disposal of hazardous solid wastes. The sponsors planned to employ a licensed transporter to take away any such wastes to a licensed disposal site. TSCA might have affected the sale of the liquid fuel byproducts; however, the sponsors foresaw no insurmountable obstacles.

Through October 1980, the sponsors had spent $2.2 million, reimbursable by DOE, on environmental testing and permits. EPA also required additional toxicity testing, at a cost of $820,000. The sponsors estimated pollution control and safety measures at the plant would cost $28 million. Finally, DOE envisioned a need for research to evalute long-term environmental impacts or chronic health effects.

HYGAS PROCESS DEMONSTRATION

The Institute of Gas Technology, which has been researching coal gasification for 35 years, has developed and pilot tested the Hygas process to gasify strongly caking coal at a high temperature and pressure. The Institute, together with Texas Gas Transmission Company and the State of Kentucky, has tried but failed to obtain DOE funding to design and build a commercial-scale demonstration module in western Kentucky. However, DOE did fund a "conceptual" design for such a module, which could be adapted to a specific site.

Focus has been on perfecting process

The Institute of Gas Technology is a nonprofit research corporation affiliated with the Illinois Institute of Technology

and funded by the Gas Research Institute (GRI), the Federal Government, and industrial sponsors. It is involved in numerous energy projects, not all of which involve gas. One process it developed was selected for a DOE-funded demonstration of coal conversion to medium-Btu gas.

The Institute's work on coal gasification began in 1946. By 1964 it had invented the Hygas process and was ready to test it. It obtained $3 million from the American Gas Association (an industry group) and the Federal Office of Coal Research (a forerunner of ERDA) for a process development unit--a gasifier 4 inches in diameter. The two sponsors then supplied $92 million to build and operate a pilot plant with a gasifier about 3 feet in diameter. The pilot plant operated from 1972 to 1980, running tests on Illinois, Kentucky, and Montana coal.

Around 1975, Texas Gas, a pipeline company, and Kentucky agreed to cosponsor a Hygas demonstration plant and seek shared costs with ERDA. Texas Gas is also cosponsoring the proposed Tri-State project in western Kentucky. (See p. 84.)

Site still uncertain

For a plant site Texas Gas considered some land it owned in Union County near its interstate pipeline and underground storage facilities. The plant's gas could thus be stored for sale during peak demand. Union County also offers operating mines for coal, the Ohio River for water, and communities for labor.

ERDA, however, rejected the sponsors' 1976 proposal because it was not satisfied with the contribution they offered to the construction costs. Thus, no firm selection of a site occurred. Instead, DOE provided $8 million for a generic design that could later be modified to accommodate a specific site. Thus, Hygas was a step behind two other high-Btu demonstration projects that received funds for a site-specific design in 1976.

Generic design for commercial-scale module

Looking forward to a commercial plant, though, the Hygas demonstration could have been a step ahead of its second-generation competitors, because the generic design is for a commercial-scale module. The sponsors' 1976 proposal envisioned buying out the Federal interest in the plant once the demonstration is complete and expanding it to commercial size by adding two process trains of the same scale.

Essentially, then, all the technical risk would have been taken in the scaleup from pilot plant to demonstration plant, a scaleup of 80 times. Institute officials, confident of the project's success, consider this approach ideal. They conceded,

however, that someone who is skeptical of the project's prospects might prefer a smaller scale demonstration to minimize initial risk.

Not only in scale, but also in design, the Hygas project was more ambitious than its competitors. The gasifier processes coal at high pressures--up to 70 times atmospheric pressure--through three stages. It thus forms a gas that is richer in methane than that produced by other gasifiers. In addition, the gas formed requires no additional pressurizing before it enters the pipeline.

Aside from these features, the Hygas process bears some similarities to competing second-generation processes. Like Cogas (see p. 93), it uses finely crushed coal and employs a fluidized bed to keep it buoyed up during gasification. Also like Cogas, it pumps the coal continuously into the gasifier. This feature not only speeds the processing of coal, but obviates a common source of gasifier failure, the hopper that feeds coal into a conventional gasifier. Thus, the Hygas design requires no spare gasifiers, only spare pumps. The design shares with the slagging gasifier demonstration (see p. 88 and 99), the combining of shift and methanation. However, because the gas leaving the gasifier is richer in methane, the need for these processes is reduced, which the developers say results in greater efficiency.

The ultimate efficiency of the demonstration plant is a bone of contention between the developers and DOE. The pilot plant was too small to simulate certain conditions that the developers believe will improve efficiency in the full-scale gasifier. DOE considers this claim doubtful and believes the generic design should be revised; thus, it proposed the rescission of $5 million that the Congress appropriated for a site-specific Hygas design. GRI, meanwhile, is examining the economics proven in the pilot plant to determine if they are significantly worse than those envisioned for the demonstration in the generic design.

No definitive cost estimate for the Hygas project is available, since the plant has neither a site nor a site-specific design. Evidently though, the demonstration plant would have cost at least $600 million.

Financial support lacking

The 1976 proposal for the demonstration plant failed because the sponsors were not able to meet ERDA's requirement for a 50-percent concurrent contribution to construction costs. The sponsors offered to repay ERDA's extra contribution out of their share of the gas sales once the plant began operation and to buy out the Government. But this arrangement did not satisfy DOE which would be taking the risk that the plant would not work or the gas could not be sold profitably.

Texas Gas and the State of Kentucky are still interested in the demonstration. In 1980 Texas Gas submitted an unsolicited proposal for DOE funding of a detailed design, but DOE ignored it. Since then, the prospective sponsors have taken no action. In February 1981, a $30 million, multiyear State commitment to the project lapsed. Texas Gas officials say they may seek industrial partners to help finance the project once the Federal funding picture clears up.

Thus far, taxpayers, through DOE and its predecessors, and gas customers, through gas company contributions, have spent about $95 million to bring Hygas through the pilot phase. In addition, DOE funded the generic design for the demonstration plant at $8 million.

EIS not stated

Without a site for the demonstration plant, the sponsors have been unable to begin an environmental assessment that could lead to an impact statement. Environmental data collected on the site considered in 1976 will have to be updated if the plant is to be built there.

Environmental tests at the pilot plant and in the laboratory have so far cost $1.4 million. Field tests for the demonstration site were expected to cost $1.3 million. In addition, DOE was considering research beyond that necessary to comply with regulations.

APPENDIX III

Department of Energy
Washington, D.C. 20585

JAN 11 1982

Mr. J. Dexter Peach
Energy and Minerals Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Peach:

The report by the General Accounting Office (GAO), EMD 82-23, entitled "Synthetic Pipeline Gas at the Crossroads: Research and Development Needs New Direction; Commercial Demonstrations May Not Advance" makes several cases regarding Department of Energy/Fossil Energy (DOE/FE) programs to which we take no exception. It is mutually recognized that regulations often impede the efforts of both Government and industry in the commercial development of coal gasification processes. However, the subject report's critique of Fossil Energy's large scale practical demonstration projects in terms of the characteristics of routine small scale research and development (R&D) is decidedly inappropriate, and consequently entirely misleading. Although the demonstration program encompassed necessary research activities, it certainly was not a research program and was not intended to be.

Research efforts are often initiated under moderately funded programs based on projected potential, but many times the desired results are not achieved. They have low visibility so the inconclusive results are not faulted. Experiments at this research scale are planned and conducted to test hypotheses. The researchers recognize that experimental outcomes can be the desired ones, inconclusive or negative. The objectives of the Department of Energy (DOE) gasification demonstration programs were quite specific. They were to prove in commercial size applications, at least as far as cost is concerned, the promise of several R&D programs already successfully evaluated. They were the transition step between R&D and commercial applications. They were necessarily large plants with high political and public visibility. To couple typically specific, inviolable project objectives with non-specific R&D programs and equate their management methodology is not sound logic.

The GAO criticism of Fossil Energy's planning activity on the basis that: (1) the programs have not been selected to provide the "greatest benefit for the least expense;" and, (2) that the planning methodology has not been formally applied to facilitate the prioritization of long-range, high-risk projects in concert with the Administration's recent directive does not take into account the policies applicable at the time of the planning. The FE demonstration programs were procured in conformance with the legislative guidance provided by Congress and the prior Administration to concentrate on "near term" developments. The recent emphasis on long-range, high-risk research is an abrupt departure "from the moral equivalent to war" which prevailed less than four years ago. Programs provided governmental support

for demonstration activities to assure successful commercialization. A more productive evaluation of the FE demonstration programs at this point in time would measure accomplishments and failures relative to the national objectives as they were when plans were established.

More specifically, the conclusion by GAO that DOE/FE has "neglected needed environmental research" is in contradiction to action taken by DOE/FE for major gasification projects. Each project, while active, complied fully with the environmental requirements of the Resource Conservation Recovery Act (RCRA), the Toxic Substances Control Act (TSCA), and the National Environmental Policy Act (NEPA) by investigating and applying the required research which in the 1980 budget plan was forecasted for FY 1982 to be $79.7 million for liquefaction, and $29.9 million for gasification. It was the general consensus of technical and environmental advisors that further environmental research would not be cost effective. The only positive way to determine and reduce the adverse environmental effects of plant products, by-products and waste materials would be through either the construction and operational testing of demonstration plants or through direct commercial application of each mitigating process.

The Department's environmental program for high BTU coal gasification recognized the need and opportunity to obtain confirmatory long-term environmental data and to evaluate the effectiveness of measures taken to assure that the public health and safety would be protected. The confirmatory effort was conducted at existing Department facilities. This program was targeted at mutually determining and reducing the risk to public health. The GAO report singled out Department management for drastically reducing process specific environmental research relating to high BTU coal gasification in particular (pages 22m 23m abd 33,) 1/

The GAO report implies programmatic and budgetary uncertainty relative to health, safety and environmental activity. Department environmental research historically has been an integral part of the programmatic activities. The recent redirection of FE programs toward longer range coal research has reduced the requirement for an accompanying Department health and safety program. However, the environmental, health and safety concerns held with respect to the demonstration projects still exist and are the responsibility of the project's sponsors.

In recognition of this and applicable legislation, the proposers for financial assistance for the Colony shale project and the Great Plains gasification project included plans for environmental monitoring and process stream and effluent testing for environmental effects. The Department, in consultation with the SFC, reviewed these proposals and recommended further actions to improve knowledge of environmental effects. The Colony agreement has been finalized, and the Great Plains agreement is rapidly nearing finalization.

1/Page references have been changed to correspond to those in the final report.

The GAO report speaks to the lack of documentation interrelating the Department's process demonstration program with its environmental research activities while not recognizing that prior GAO studies have critically commented on the Department's formalized environmental planning activity - i.e., technology specific Environmental Development Plans. This joint Fossil Energy-Environmental Protection Agency planning activity should have been referenced because it resulted in the preparation and execution of detailed, model site-specific environmental assessments at operating synfuel facilities - e.g., the Stoic gasifier at the University of Minnesota at Duluth and the H-Coal pilot plant at Catlettsburg, Kentucky.

The DOE/FE demonstration program had been expected to succeed in its objectives by proving commercial viability without the need for further R&D. Thus, DOE/FE heavily depended upon the Institute of Gas Technology (IGT), the Energy Technology Centers and research laboratories who are geared to small scale, less costly research for investigation of "novel processes with exceptional promise."

It is always difficult to understand and satisfy near-term, mid-term and long-term research unless the time frames and the specifications for commercial accomplishment are universally defined. DOE/FE has funded many R&D programs performed under contract, including work done by IGT. The IGT proposed work in total is reviewed by the Department's Federal Energy Regulatory Commission and is approved in principle while the cost shared IGT/DOE work is reviewed and approved by FE. The quotation of "advanced . . . research would be completed in the near-term (the next five years) but the benefits would occur in the mid-term (up to the year 2000) when . . . commercial plants would be expected" is not a meaningful example of planning unless it means that all IGT advanced research will be completed in five years.

Several demonstration plant designs have been developed and processes engineered by DOE/FE that are ready for capital expenditures in the field. These designs were developed concurrently with the pilot plant programs. Continuation of Department efforts with respect to demonstration plants would have produced gas within five years. The Department recognizes that the phrases "long-term," "high-risk" and "high-payoff" are not precise delineators that can be mechanically used to determine which projects fall within the scope of its R&D programs. The very nature of the project selection process for R&D funding demands a strong degree of flexibility. The definition of "long-term" is a function of the planning horizon used by the private sector differing for particular industries.

In the synthetic fuels area, the Department's R&D activities are presently dedicated to establishing the technology and engineering base from which industry can bring economically competitive and environmentally acceptable new technologies into the marketplace. Federal involvement, however, will be limited to those promising areas of energy technology where the private sector is unlikely or unable to invest. But drawing a precise boundary line to determine these limits would at best be arbitrary. It will vary from technology-to-technology and depend upon the ultimate commercial project size, complexity, uncertainties, and competitive economics, and would

APPENDIX III

have to be redrawn continually as market factors change. The choice of which projects are long-term, high-risk and high-payoff is best left to R&D program managers who have the technical perspective to make the necessary judgments concerning the potential benefits of the project. An across-the-board textbook approach cannot substitute for professional judgment.

In conclusion, we cannot concur with the report in general, but do agree with the recommendation (p. 41)1/that an energy research and development program should be funded according to national priorities and that any research more appropriately funded by industry should be eliminated from current budgets as swiftly as feasible. This philosophy is well reflected in our amended budget request for FY 1982 which was submitted to Congress last September.

Sincerely,

William S. Heffelfinger
Assistant Secretary
Management and Administration

1/Page reference has been changed to correspond to that in the draft.

United States Synthetic Fuels Corporation
1900 L Street, N.W. Washington, District of Columbia 20586 Telephone: (202) 653-4400

December 9, 1981

J. Dexter Peach, Director
Energy and Minerals Division
United States General Accounting Office
Washington, D. C. 20548

Dear Mr. Peach:

Thank you for the opportunity to review and provide written comments on the draft GAO report on high-Btu coal gasification dated November 1981. In order to provide timely written comments, Chairman Noble has asked me to respond . In addition, the report has been reviewed in informal discussions between SFC and GAO staff.

The subject report touches upon and provides useful perspective on many issues regarding the proper role for Federal agencies, private industry, and the Synthetic Fuels Corporation in the development of improved national capabilities for producing synthetic substitutes for conventional oil and gas. However, the report's emphasis on high-Btu gas and a limited set of "second generation" coal gasification technologies seems to unnecessarily narrow the range of focus.

As the report notes (p. 30 and App I),1/ production of many synthetic fuel products begins with an initial gasification step to produce "synthesis gas" that can then be either burned directly (industrial fuel gas) or processed into a number of synthetic fuel products ranging from high-Btu gas to methanol, to gasoline and middle distillates. For all of these approaches, coal gasification is a key step.

The report emphasizes the three DOE-supported coal gasification processes that process Eastern caking coals and were originally oriented toward a high-Btu pipeline gas market. However, the range of available and developing options for the key coal gasification step is much broader than these three processes, while prospects for high-Btu pipeline gas supplies as compared to liquids are now brighter than they were several years ago. Thus, the report's emphasis on technologies oriented toward high-Btu gas supplies seems to narrow the focus in a manner counter to that of the marketplace.

1/Page references have been changed to correspond to those in the final report.

APPENDIX IV

While the emphasis in the report may be understandable given the need to review past DOE programs, the Synthetic Fuels Corporation must look forward toward future market needs. If "second generation" technologies are technically ready and have worthwhile economic or performance advantages, private sponsors may propose projects incorporating those technologies to the SFC. Indeed, several projects already before the SFC expect to use advanced gasification technologies. The Corporation recognizes the value of demonstrating an appropriately diverse technical capability. Thus, we are and will be considering proposals incorporating new technologies carefully along with others.

The primary recommendation of the report is that the Department of Energy prepare a report on its second generation coal gasification development program. Such a summary report evaluating technical status as well as economic and environmental performance is an important product of any technology development program, that could be useful to many persons and organizations. Moreover, Secretary Edwards and the DOE staff have been most helpful in providing Corporation management and staff with briefings and other technical information as necessary. Thus, any report on the DOE high-Btu gas program need not be directed specifically to the Synthetic Fuels Corporation.

If another DOE study on coal gasification processes is to be done, it might be more useful if it provided data on all coal gasification technologies including those oriented toward synthesis gas production and those being developed by the private sector. Such a broadened report could help put into perspective the many products and technologies available for coal-based synthetic fuels.

Sincerely,

Victor A. Schroeder
President

FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON 20426

IN REPLY REFER TO

DEC 9 1981

Mr. J. Dexter Peach
Director, U.S. General
Accounting Office
Washington, D. C. 20548

Dear Mr. Peach:

The Chairman has reviewed the draft report "Synthetic Pipeline Gas at the Crossroads: Research and Development Needs New Direction" and has no comments to provide.

We appreciate having the opportunity to review the draft report.

Sincerely,

William G. McDonald
Executive Director

cc: Secretary Edwards

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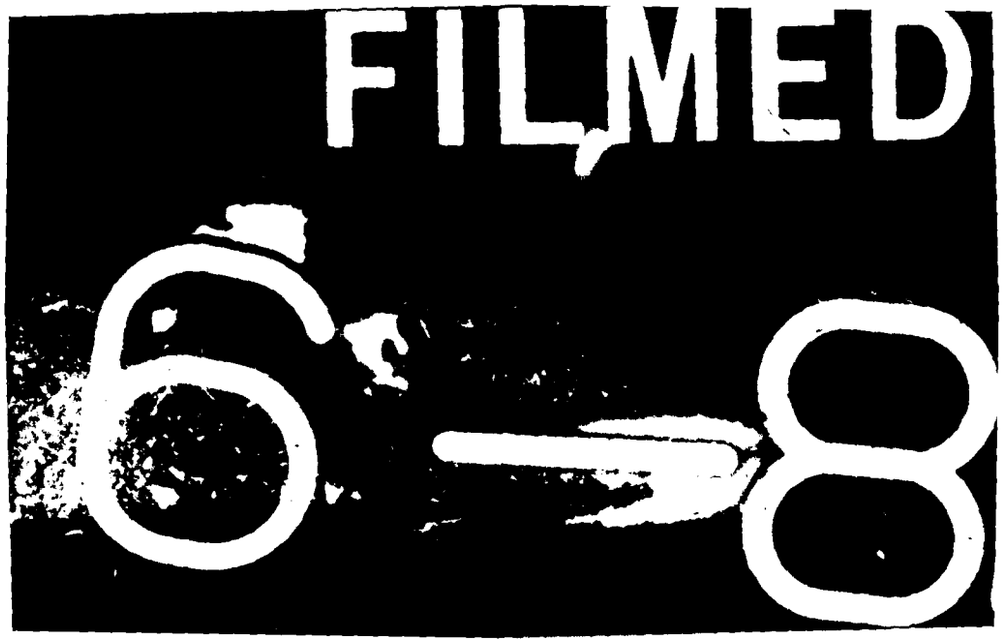
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